POWER

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Superpower

THERE are few who understand the superpower plan in detail, but the public does not understand it in general.

Even men in the business regard it as a collection of extra-large power houses and say that the superpower station of yesterday is the ordinary plant of today.

Perhaps they make a difference between the superpower station and the superpower plan, although they mingle them in writing and in conversation.

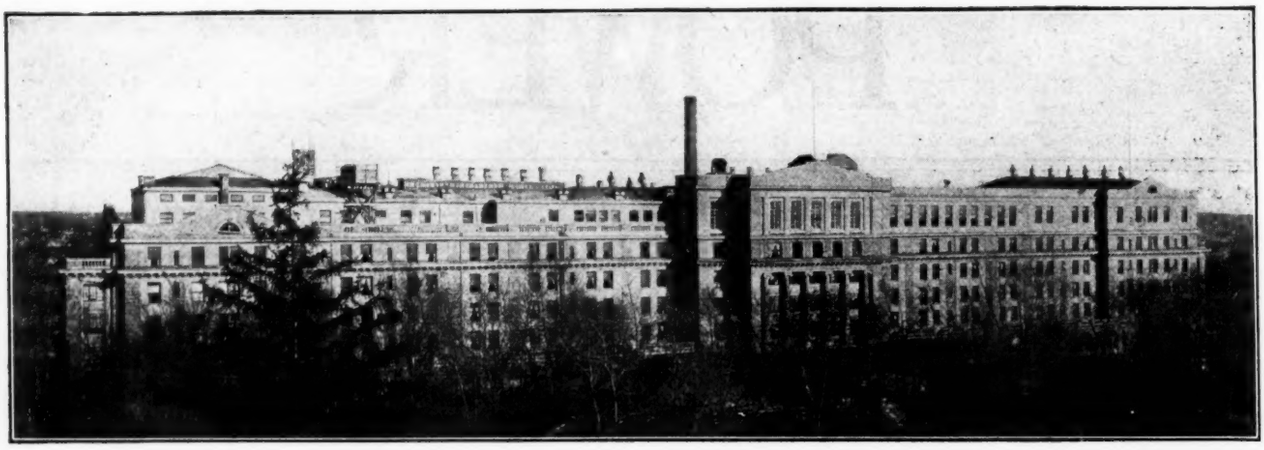
Look over an industrial city block of a few years ago. There are in it a dozen or twenty separate power plants. On the back street several small industries, each with its boiler and engine, coal carts from different dealers backing up and leaving the fuel, a ton or two at a time. Oil, packing and supplies bought in driblets. No one of them big enough to support a real engineer. On the main street some office buildings with more pretentious and efficient power plants, but the aggregate employing many more men than were needed, burning more fuel and paying more for their supplies than would be necessary in a well-designed and operated plant that could furnish not only power, but light, heat, hot and cold water, compressed air, vacuum, refrigeration, etc., to the entire block.

Extend this idealization to a section of the country instead of to a city block, and you have a conception of the superpower plan.

Only the superpower plan does not contemplate merely building a single immense power station for each industrial block or district and tying them all together It proposes an intelligent engineering study of the power needs and the available sources of power supply for a district and a combination and co-ordination that will give to each subdivision of the district a dependable supply of power in the cheapest and most economical way.

It is the organization, the systemizing, the rationalizing of the power resources of the country.

And it is time that somebody began to think of power in that way; to look ahead to the time when the world will have to decide the purposes for which fuel may be burned and power used; to pick the essential industries. This time is already in sight so far as liquid fuels are concerned.



New Boiler Plant for Battle Creek Sanitarium

Installation of modern boiler house well equipped for mechanical operation saved 10 tons of coal a day and eliminated the services of nine men from the operating force. A full complement of instruments give all essential operating data and make it possible to keep the plant at its best.

ALTHOUGH Battle Creek is known country-wide as the Nation's health capital, only those who have actually seen the place, can visualize the physical proportions of this institution. Its mammoth guest buildings, hospital, dormitories, college buildings, greenhouses and thirty cottages occupying a site of 43 acres, create demands for heat, light, refrigeration and water for general purposes, baths and swimming pools that can be met only by a fair-sized power plant. In addition to the variety of services mentioned, steam at high pressure is supplied to the kitchen and laundry and to direct-acting hydraulic-elevator steam pumps.

It has been the policy of the sanitarium to meet these demands from a private plant of its own, adding to the equipment as the needs of the institution warranted. In this way the engineering department had gradually acquired a boiler room consisting of six return-tubular boilers equipped with underfeed stokers, but without mechanical coal and ash handling, an engine room containing for the most part engine-driven belted units for generating both direct and alternating current, two absorption refrigerating units aggregating 40 tons for refrigeration and icemaking, compound steam elevator pumps in the main building and the annex, and in the latter a three-boiler plant operated in winter to help care for the heating load.

Mechanical Equipment Was Scattered and Becoming Obsolete

As will be evident from the foregoing, the mechanical equipment was more or less scattered, much of it was becoming obsolete, the efficiency was not up to standard, thirteen men were required to insure 24-hour service, and the capacity had become inadequate to meet growing demands. This was particularly true of the water-pumping equipment. The requirements had become so great that it was necessary to install a special battery of centrifugal pumps discharging directly into the line without the usual protection afforded by a storage tower or a compression tank. As neither steam nor electrical energy was available in sufficient quantity to carry the pumping load, motors were attached to the pumps and purchased current used as the driving medium.

It became evident that it would pay to install a modern plant in which the steam, electric and refrigerating machinery might be concentrated. At the time the decision was made, prices were high and the business depression at its height, so only immediate necessities were met by the installation of a modern boiler room, with plenty of room for expansion and provision for the early erection of an engine room to contain the electrical generating and refrigerating equipment.

New Boiler Plant Now in Operation

This boiler house has been erected and has been in operation for some months. It was designed for efficient operation and is mechanically equipped to reduce labor to a minimum. As an evidence of the success of the design it may be stated that the operating force for 24-hour service was reduced from thirteen to four men, the latter figure including the boiler-room foreman. All last summer the saving in coal averaged ten tons a day, and a greater reduction in fuel during the colder months is anticipated.

The new boiler house is of brick and concrete construction, with window area extending almost to the roof to provide an unusually light and cool interior. The engine-room extension will be made on one side of the boiler house. Between the two plants is an open concrete-lined pit with a capacity to store 10,000 tons of coal, and at the left are the water-softening and pumping installations.

Fig. 2 shows the present boiler equipment, consisting of four water-tube boilers, each containing 5,000 sq.ft. of steam-making surface and arranged in batteries of two, on one side of a central firing aisle. The opposite side of the aisle has been reserved for a future line of boilers similar in size and number, when they are required, although at present the space is being used temporarily as a steamfitting and plumbing shop. Setting the center of the mud drum 4 ft. above the floor was considered amply high to give sufficient furnace volume for the type of stoker employed. The latter are underfeed stokers with five retorts per furnace. They were selected to burn the nut and slack coal from West Virginia and Kentucky used in the plant and to take

care of the fluctuations in the load occurring principally during the heating season. To give good furnace conditions, operation in the vicinity of 200 per cent of rating will be maintained.

For the new engine room the operating pressure will be 150 lb. gage, but at the present steam is generated at a pressure of 115 lb. and distributed at this pressure through connecting tunnels to the old engine room, 300 ft. away; to the elevator pumps in the main building and the annex, distant 500 and 1,200 ft. respectively, and to the laundry and kitchens. For heating, the pressure of the live steam is reduced at the point of service. Exhaust steam from the compound elevator pump is utilized for heating domestic hot water and to some extent for heating the building, so that the loss in transmission is more than compensated and the steam utilized at a high degree of efficiency.

Each battery of two boilers has its individual forced-draft fan, which is driven directly by a 45-hp. steam turbine, the steam drive being selected to insure, for the present at any rate, dependability and to give a supply of exhaust steam for the feed water and the heating of greenhouses in the immediate vicinity. Each blower has a capacity to deliver 27,700 cu.ft. of air per minute at a static pressure of 5 in. when revolving at 1,674 r.p.m. Automatic regulation from the steam pressure is provided. The fans discharge into a common duct running beneath them for the full length of the two batteries of boilers, with a sectionalizing damper so that either fan may be used on either battery or, as in normal operation, supply the two boilers to which it is attached. The fan unit also drives the automatics controlling the stokers by means of the two overhead shafts, cross-connected as indicated in Fig. 1 and receiving their driving force from a pulley on the end of the fan shaft. The two sections of jackshaft under the automatics may be coupled together to give breakdown service for either unit when required.

Coal for the plant is received on a siding one-half mile distant from the boiler house. From bottom-dump cars it is discharged into a track hopper and then elevated into an overhead bunker from which it is loaded into 4-ton automobile trucks to be conveyed to the plant. Here it may be dumped directly into the open storage previously referred to or through a grating in a driveway at the side of the boiler house into a receiving hopper. The grating separates the fine coal from the lump or, if the coal is of uniformly small size, may be removed entirely. From the hopper the coal passes to an apron conveyor feeding a two-roll crusher at its opposite extremity, located over the conveyor tunnel, which passes under the boiler-room floor. The crusher is run only when it is necessary to use lump coal for by separating the crusher rolls fine coal is

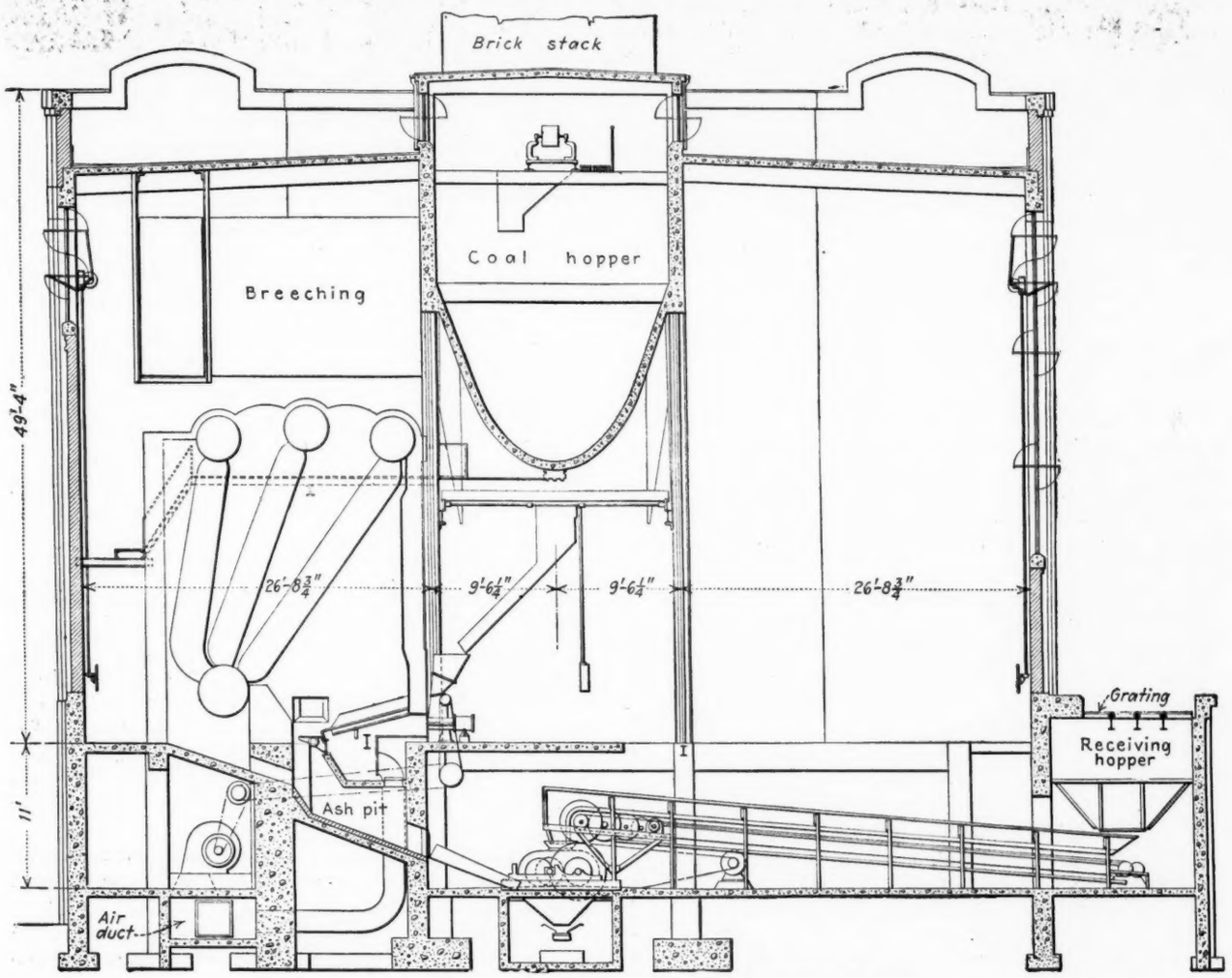


FIG. 1. VERTICAL SECTION THROUGH BOILER HOUSE

passed through to a continuous bucket conveyor, which makes the circuit of the boiler room and delivers to an overhead reinforced-concrete bunker having a capacity of 400 tons. This bunker is inclosed, as indicated in Fig. 1, so that no coal dust can find its way into the boiler room, and above, a monitor roof provides light and ventilation.

The conveying and crushing equipment is motor-driven and has a capacity to handle 30 tons of coal an hour. In the conveyor tunnel much of the piping is concentrated, so that it will be readily accessible and leave the boiler-room floor free of complications.

From the bunker the coal may discharge through any one of eight sliding gates chain-operated from the boiler-room floor into a one-ton hand-operated traveling weigh larry which stamps on cards the weight of coal delivered to the boilers.

Ash hoppers underneath the stokers are lined with paving brick and slope toward the conveyor tunnel under the central firing aisle, so that by means of a portable chute the ashes may be raked directly into the continuous bucket conveyor serving the double purpose of handling coal and ash. A stationary tripper delivers the ash into a receiving hopper and spout discharging into an ash-storage space in the base of the stack. A sloping bottom is provided so that the ash will flow into a discharge chute leading outside the building to deliver to automobile trucks. Storage of ashes in such a place is unusual, but in the present case was made possible by the installation of a hollow reinforced-concrete base supporting a brick stack. The concrete foundation rises 38 ft. above the basement floor to a point just below the breaching opening into the stack.

As far as draft is concerned, the interior of this foundation is of no particular benefit, so it has been

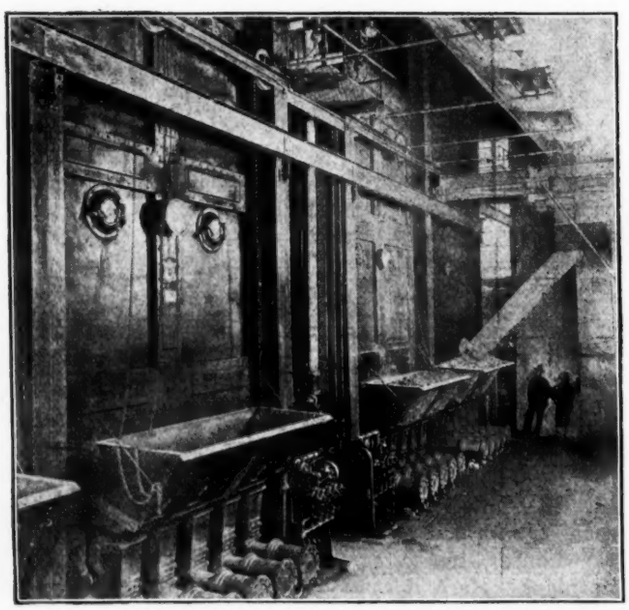


FIG. 2. VIEW OF BOILER FRONTS SHOWING STOKERS AND TRAVELING WEIGH LARRY

utilized not only for an ash hopper, but also as a general storage room located beneath the ash storage. A concrete wall separates the stack from the ash hopper, but undercut gates, which may be opened from the outside, are provided as a passage for the soot from the chimney into the ash storage. To prevent spawling of the concrete which might endanger the stack, due to the hot soot and gases, the floor of the chimney is protected by a layer of insulating brick. The section of the ash chute from the conveyor where it passes through the base of the stack and is exposed to the hot gases is made of

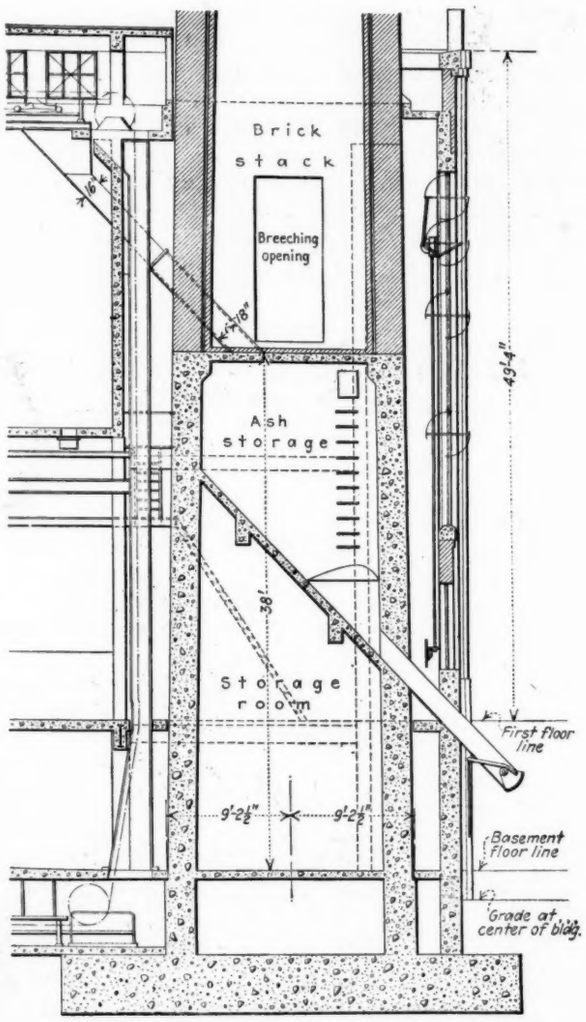


FIG. 3. CONCRETE BASE OF STACK USED FOR ASH STORAGE

cast iron 1¼ in. thick on the bottom and sides and 1 in. thick on the top. The inaccessible location makes this construction desirable.

In the feed-water system a number of interesting features have been developed. Returns from the heating systems and all other uses come back by gravity to a large horizontal storage tank in the basement of the plant. This tank is used as a purifier to separate any vestige of oil or sediment that may be in the condensate. As shown in Fig. 4, the entrance to the outlet pipe is 12 in. above the bottom of the tank, so that the heavy particles of sediment that will collect at the bottom of the tank will not be drawn off, nor will the oil which will collect on the surface of the water. The tank is placed at such a level in relation to a pump and receiver outfit in the basement that the water flows by gravity to the receiver as it is removed by the pumps. Once a week the tank is blown out thoroughly to get rid of any collection of oil or sediment. To prevent siphoning, the outlet pipe has been vented and an overflow connection provided on the discharge line, so that if the returns come back faster than it is possible to use them,

the excess passes to a second storage tank provided for this purpose.

As previously intimated, the condensate finds its way to a receiving tank from which pumps deliver it to the feed-water heater. The operation of these pumps is controlled by a float in the heater, but in case the water should get low in the receiver, there is also a float here to shut down the pumps. Then, as the water line drops lower in the heater, the float will open the makeup-water valve, admitting softened water from the supply system of the sanitarium. As a last reserve there is also provision to take city water.

When the new plant was first started up, the engineering staff had an interesting problem to solve in connection with the water supply. This water is taken from three 8-in. wells by a battery of motor-driven centrifugal pumps. To remove the scale-forming matter, it had been treated with lime and soda ash in a continuous-type, cold treatment softener having a capacity to deliver 30,000 gal. an hour. Owing to a large increase in the demand for water, the supply delivered from the softener did not get the opportunity

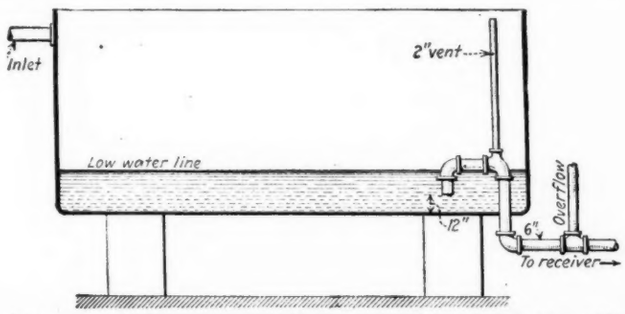


FIG. 4. CONDENSATE STORAGE TANK IN WHICH OIL AND SEDIMENT ARE TRAPPED

to settle properly, and considerable after-precipitation took place in the boilers, domestic hot-water heaters and in the pipe lines. Conditions became so bad that it was necessary to improve the treating plant. Rather than install a new outfit of greater capacity, the old softening equipment was retained and the water from it, containing about 8 grains per gallon of incrusting solids, was first passed through two new clarifying filters of the pressure type and on to a new installation consisting of three water softeners, each having a maximum rated capacity of 133,333 gal. for ten hours. In the new installation the water is reduced to practically zero hardness, and the troubles previously experienced have disappeared. Practically no scale forms in the boilers. They are opened up once a month, and any sludge or impurities present may be washed out with a hose. The pipe lines are no longer obstructed, and the hot-water heaters give much better service. In fact, five heaters now do the same work that required eleven heaters before the change in the water softening plant was made.

For a four-boiler plant it is remarkably complete with instruments. Each boiler has a flow meter with an indicating instrument on the boiler front and a recording and integrating meter in the chief engineer's office, 500 ft. distant. The feed-water and the makeup also are

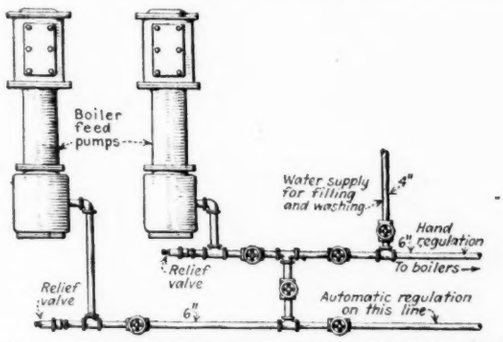


FIG. 5. DIAGRAM OF FEED-PUMP CONNECTIONS

metered, and the readings obtained may be checked with the records from the steam-flow meters.

U-gages measure the forced draft supplied the stokers, and differential draft gages measure the draft over the fire, below the damper, or the drop through the setting. Recording thermometers give the temperature of the flue gases, another instrument records the feed-water temperature, and a recording pressure gage gives

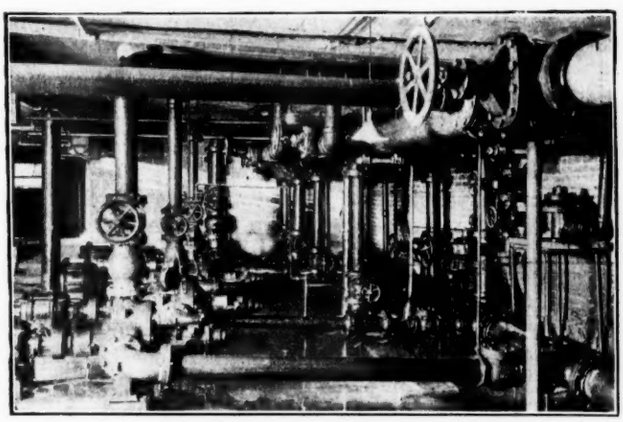


FIG. 6. WATER PUMPING PLANT IN SOFTENER BUILDING

the steam pressure. An automatic CO_2 recorder serves each battery of boilers.

A. W. Grabe, consulting engineer, of Milwaukee, designed the new boiler house. John R. Carter, who supervised the construction, has recently succeeded Bert E. Clough, who has been chief engineer for the last 17 years.

PRINCIPAL EQUIPMENT OF BATTLE CREEK SANITARIUM BOILER HOUSE

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
4	Boilers	Stirling	5,000-sq.ft.	Generate steam	115 lb. press., underfeed stokers	Babcock & Wilcox
4	Stokers	Underfeed, Jones A.-C.	5-retort	Serve boilers	Controlled by Cole automatics	The Underfeed Stoker Co. of America
2	Fans	Stoker	27,700-cu.ft. per min.	Forced draft	Turbine-driven, 1674 r.p.m.	Buffalo Forge Co.
2	Turbines	Single-stage	45-hp.	Drive fans	Controlled by Mason regulator	Terry Steam Turbine Co.
1	Stack	Brick	225 ft. high, 10 ft. dia.	Serve boilers		Alphons-Custodis
1	Conveyor	Apron-feeder	30 in. wide	Delivers coal to crusher	Driven by 3-hp. G. E. ind. motor	Link-Belt Co.
1	Crusher	Two-roll	30 tons per hr.	Crush coal	Driven by 15-hp. G. E. ind. motor	Link Belt Co.
1	Conveyor	Peck carrier	30 tons per hr.	Coal to bunkers	Driven by 10-hp. G. E. ind. motor	Link-Belt Co.
1	Weigh larry	Traveling	1 ton	Weigh coal to boilers	Hand-operated, stamps weight	Link-Belt Co.
1	Heater	Open	100,000 lb. per hr.	Heat feed water	Float control of water supply	H. S. B. W. Cochrane Corp.
2	Pumps	Receiver type	6½ x 10 x 10 in.	Condensate to heater	Under float control	Union Steam Pump Co.

Crane stop and check valves; Crane steam valves; Crane water valves; Babcock & Wilcox blowoff valves; Crane safety valves; Craig damper regulators; Copes feed-water regulators; Cochrane V-notch meter on feed water; Enare meter on makeup; Republic steam-flow meters; Schaeffer & Budenberg, 4 gages on forced draft; Hays differential draft gages; Republic and Hays CO_2 recorders; Foxboro recording thermometers on flue gases; Taylor "Tycos" recording thermometer on feed water; Ashton recording steam-pressure gage; Ashcroft steam-pressure gages; Mason steam-pressure regulators.

Effects of Sulphur in Fuel Oil

The Presence of Sulphur in Fuel Oil Is Detrimental, But Its Deteriorating Effect Can Be Largely Avoided by Adopting Proper Precautions

By ALLEN F. BREWER

THE detrimental effects that sulphur in fuel oil may have on storage tanks, boilers, stacks and firing equipment are becoming of serious moment to power-plant operators, as heavy crude oils appear in more and more prominence to replace higher grades of distillate or residuum fuel oils for firing purposes. Until comparatively recently, with the latter oils available and most preferred as fuels, this question of sulphur has been practically disregarded, owing to the probable low percentages of sulphur content.

It is interesting to note the percentages of sulphur usually present in the most common grades of fuel oils. For example, in the so-called light fuel oils of gravity around 26 deg. Baumé, sulphur will seldom exceed 1.5 per cent; in fact, this is the maximum allowable percentage for United States Navy standard fuel oil of a gravity ranging between 20 and 23 deg. Baumé. In blended fuel oils, such as the so-called bunker A and B oils, the allowable sulphur content is raised respectively to 2.75 and 3 per cent. Next in order would come the topped oils, or reduced crude residuums, from which just the lighter distillates have been removed. In such oils the maximum sulphur content is generally specified at 4 per cent.

Sulphur in Most Fuel Oils

Finally, we would have to do with pure crude oils, such as heavy Mexican, for example. In these fuels the sulphur content is decidedly varied, ranging from 3 to 6.5 per cent as an accepted maximum. It is with the latter oils that the stationary boiler operator must bring himself more and more to acceptance and use. The day of lighter, high-grade crudes as fuels, such as found throughout the Appalachian, mid-continental and gulf-coast sections of the United States, has practically passed. These oils are too valuable for refinery purposes to expect or contemplate their continued use as fuels except in emergencies or isolated cases. Summing up, therefore, if petroleum is to be used as fuel in the future, barring special cases where residuum oils are available, such as in refinery districts, the stationary-boiler plant will have to adapt itself to the heavier crude oil as its most dependable liquid fuel, from the point of view of certainty of delivery. True, at frequent intervals the plant will probably be able to obtain a shipment of some one of the lighter fuel oils, such as have been briefly mentioned, but in fact, since the sulphur content in any of these oils (below 3 per cent) is considered so low as to be negligible, they will not be discussed further. In general their use today is practically barred to the smaller plant because of excessively high cost.

Does Not Harm Fuel Oil

Sulphur as an element is of practically little detriment to the fuel oil alone, except that in higher percentages it will result in the latter having a somewhat lower calorific value per pound or per gallon, etc. If we could maintain sulphur in such a state of purity throughout combustion, we would have relatively little to fear. However, as the fuel is burned, the sulphur present will be oxidized first to sulphur dioxide. Some hydrogen sulphide will, as well, be formed from the union of sulphur and hydrogen in the oil when combustion takes place. As a later reaction, sulphur dioxide will be converted to sulphur trioxide in the presence of oxygen.

These reactions even so far would be relatively harmless except for the unavoidable presence of water vapor in the furnace. The source of the water is threefold, in a steam atomizing system—from the steam used for atomization of the fuel, from the oil itself (and all fuel oils will contain a certain amount of free water no matter how long they may have been allowed to stand and settle), and from the chemical reaction occurring upon combustion between hydrogen in the fuel and the oxygen in the air, which results in the formation of water vapor.

Formation of Sulphuric Acid

It is well known that in the presence of water vapor, sulphur dioxide will react to form sulphurous acid which, being unstable in the presence of oxygen, will accordingly change to sulphuric acid. Also, sulphur trioxide will combine with water vapor to form sulphuric acid.

It is therefore evident that while we are dealing primarily with the question of sulphur and its compounds in the oils, yet water is an aiding and abetting factor to resultant damage; it is far easier to decrease this action by allowing the oil to stand and settle the water out, than to reduce the total sulphur content, for this latter can only be controlled and decreased in its percentage, either by using a higher-grade oil (which is believed by many to be a coming practical impossibility) or by resorting to expensive chemical treatment.

Furthermore, not only are we concerned with free sulphur, but as well, in practically every petroleum there will exist certain acid-forming, organic sulphur compounds. Of their exact nature but little is known; still, the general idea is prevalent that upon combustion of the oil and the elevation of these compounds to furnace temperatures, and probably in the presence of water vapor, they will set up an acidic reaction upon metallic surfaces with which they come in contact. More especially is this true if these surfaces are permitted to cool down intermittently and sooting is allowed to occur to an extensive degree. In this matter of organic sulphur compounds petroleum fuels differ from coals and involve more possibilities of damage to heating surfaces, though less to storage and handling equipment. In most coals the sulphur exists chiefly as pyrite, and the resultant reaction is almost entirely a burning to sulphur dioxide and hydrogen sulphide. The presence of water or water vapor is an essential factor to its further reaction to more complex sulphurous and sulphuric acid compounds.

In bulk storage in steel tanks the possibility of free or compounded sulphur in an oil doing any extensive damage is remote. In order for this to occur, of course

an acid reaction must take place, and the presence of water or more particularly water vapor, is practically essential. During pumping water will probably be contained throughout the body of the oil, but after a period of standing most of it will settle to the bottom of the tank (depending of course on the weight of the oil), from which it can be pumped off. With a heavy oil this process of settling will require a longer time, and it is always advisable, where possible, to allow several days to elapse, and draw the fuel from a reserve tank if one is available. If any acid reaction does occur, due to water particles uniting with the sulphur or its compounds during the settling process, it will probably be at the bottom of the tank and around the first ring. To insure against this possibility, it is customary to coat the bottom of the tank and first ring with an acid resisting paint or some form of "asphalt dope." In concrete storage tanks, as far as has been determined, there is no damage resultant from sulphur in either free or acid compound state.

Free from Corrosive Action

Oil-fuel piping, pumps, heaters and firing equipment will, in general, be relatively free from corrosive action due to sulphur acids, if the water in the bottom of the storage tank is regularly drawn off and its level kept below the inlet of the oil suction pipe. As well, especially with a heavy asphaltic-base oil, there will be deposited a coating of tarry residue as a lining within the heater and piping, etc., which will serve as an excellent preservative against corrosion from acids. This lining, however, is cumulative to a remarkable degree, especially when a heavy oil is used and if the temperature is relatively low. Therefore, the heater, pump barrels and piping should be periodically cleaned of the bulk of this tarry deposit. The former two can be cleaned by removing heads, etc., and scraping; and the piping by connection with a jet of live steam and allowing it to blow through for several minutes. It is never advisable to scrape or clean to the bare metal, since it will result in the exposure of a fresh surface to the possible action of the acids.

Effect on Boiler Shell

The possibility of sulphur having a detrimental effect on boiler shell, tubes, flues and stack, if the latter is of steel, will depend largely upon the extent to which water leakage occurs, the degree of soot that is allowed to accumulate, the amount of water vapor entering the furnace, either as water in the oil or as atomizing steam, and the temperatures maintained. In boilers that are alternately heated and allowed to cool, owing to intermittent operation, there will be greater opportunity for sooting of the heating surfaces, and the probability of leaks around tubes and headers will be increased. Sulphur compounds will have a tendency to accumulate in soot formations when the boiler is cooled down, and in the presence of moisture it is evident that corrosive acid reaction will practically be a certainty.

On the other hand, if a boiler is fired constantly and a uniform degree of heat maintained, the tendency of soot to accumulate will be materially decreased, provided the firing is done in an efficient manner and the tubes are blown frequently with some form of soot blower. Also, moisture or water vapor from any source will have less opportunity to come in permanent contact with boiler-heating surfaces and flues to be absorbed by any soot thereupon, due to the velocity of the current of waste gases which will carry such vapors into the stack. Thus, they will have scarcely time to react with any sulphur compounds that may be present in the waste gases or contained in soot deposits. With a sufficient and proper degree of heat in the waste gases their velocity up the stack will be so great that the probability of acid reaction damaging the latter, if it be of steel, is believed to be almost as slight as in the previous passages of the boiler.

Corrosive action of acidic sulphur compounds on economizer tubes and scrapers is practically as probable as in any other prior part of the boiler equipment. The same elements of soot, water vapor and alternate heating and cooling all must be considered as before. However, owing to the custom of using cast-iron tubes and scrapers, the detrimental effects are postponed to a degree. It is well known that cast iron shows better resisting qualities to acid reaction than do steel or wrought iron. On the other hand, the action of tube scrapers tends to expose continuously a fresh metallic surface to any acids that may be present, and even cast iron will be attacked ultimately under such conditions. Another factor to be considered is that the temperatures of waste gases existing in economizers are lower than in the boiler or flue passages. At such lower temperatures, probably around 300 deg. F., it is believed by many that sulphur acid reactions will be materially hastened.

Sulphur a Menace

In final it may be said that the detrimental effects of sulphur are a menace, but they can be materially prevented, it is believed, by avoiding boiler shutdowns as much as possible, maintaining constant and uniform temperatures, allowing the bulk of the water properly to drain from the oil before firing, taking care to use as little steam as possible to atomize the oil, blowing tubes frequently to prevent sooting, and firing efficiently and economically with as little smoke as possible. We cannot (as a general rule for fuel oils) remove the cause, sulphur, from the oil, but by proper observance of the accepted recommendations stated, we can cut down the effects markedly, and every effort should be made by all fuel oil operators, to this end. Ultimately, it will prove in the interests of their personal welfare in all probability, the life of the boilers and accessories, and the conservation of fuel and heat units to the greatest degree possible.

U-Boat Diesels in Commercial Service

The German Government is endeavoring to salvage as much of the war material as possible. As a result the Hamburg-Amerika Line has had Blohm & Voss build a 6,300-ton motorship, which has been engined by two 10-cylinder German U-Boat Diesels, similar to the one described in *Power*, Dec. 13, 1921. These engines were built to operate at 390 r.p.m., but this has been reduced to 230 r.p.m., giving 1,650 b.hp. from each engine. The propellers are driven through reduction gearing.

The idea still prevails in some quarters that steam is a white visible substance like smoke, instead of an invisible gas. This impression is not unnatural in view of the fact that whenever steam escapes into the air, some of it condenses into a cloud of minute water particles. It is this hot "mist" that is mistaken for the steam itself.

Refilling Commutators

Insulation Failure in Commutators—Importance of Having Mica Proper Thickness —Assembling and Baking of Commutators

By A. HERVEY

COMMUTATOR mica frequently becomes defective from various causes, producing short-circuits between bars or a breakdown to ground. Fig. 1 shows a number of examples of how disintegration of mica takes place below the surface of the commutator. In the defects, such as at *A*, the mica has become carbonized, creating an opening into which carbon and copper dust collect, thus producing a short-circuit. In machines up to 220 volts this condition may exist until the copper segments at the defect become so hot that they are pushed up above the commutator's surface, or until a coil is burnt out; but in a 500-volt machine they usually cause a flash-over on the brushes before a coil is destroyed. If the repair is made in time, it can be very satisfactorily handled by cleaning the defects and filling with a good commutator cement. When conditions have gone beyond repairs, it is advisable to refill the commutator with mica between the bars and in some cases install new mica end rings. The *B* specimens indicate how the mica fails at the out end of the commutator, *C* is the result of an insulation failure between the ends of the segments and end ring, and *D* was caused by a ground on the back end of the commutator to the "V" ring.

In the selection of mica to be placed between bars, care must be exercised to obtain only a soft variety, particularly if the mica is to be flush with the commutator's surface. Clear white mica has the highest insulating qualities, but is is far too hard for commutator insulation. Soft amber mica is probably more widely used for this purpose than any other variety. There are on the market several grades of bar mica, varying in thickness by 0.0025 in. and ranging from 0.015 to 0.05 in. thick. The cement used in bar mica is but little affected by heat, while moulding mica becomes quite flexible when heated. If moulding mica is placed betwen the bars, the cement will ooze out while hot and form a ridge across the commutator the same as in the case of high mica.

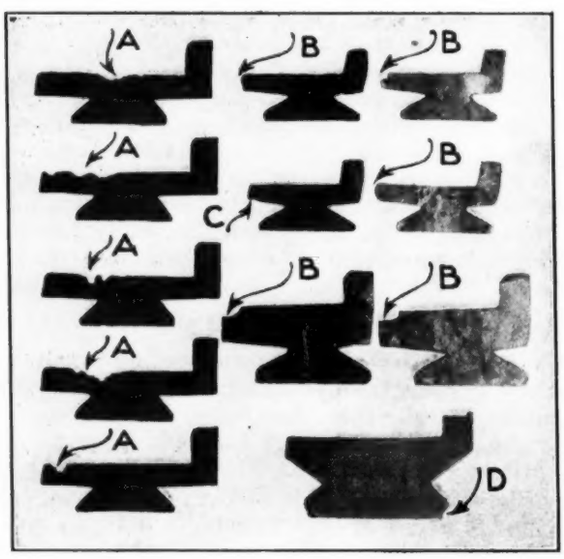
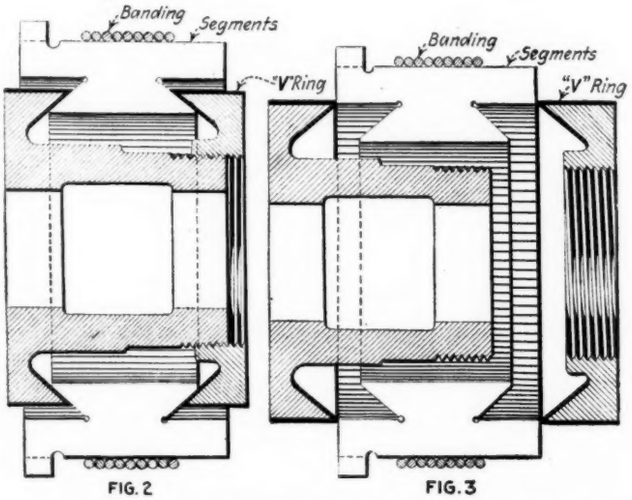


FIG. 1. SAMPLES OF INSULATION FAILURES IN COMMUTATORS

Too much emphasis cannot be placed upon selection of the correct thickness of mica. If the commutator is refilled with an oversize mica, it will be difficult if not impossible to get it together, as indicated in Fig. 2. The diameter of the commutator is increased so that the tapered surface of the "V" rings will press on but a small portion of the tapered surface of the bars. Should the mica be thin, the commutator diameter will be correspondingly small, and if clamped together before putting in the "V" rings the latter will be of larger diameter than the "V" grooves in the ends of the commutator, resulting in the condition shown in Fig. 3. On the other hand, if the commutator is loosened up to allow assembling of all parts, the "V" will seat on the bar ends without causing sufficient pressure between the segments and insulation to hold them securely. Hence



FIGS. 2 AND 3. EFFECTS OF IMPROPER SIZE MICA IN COMMUTATOR

Fig. 2.—Mica too thick so that commutator cannot be drawn up to normal size. Fig. 3.—Mica too thin, causing diameter of commutator to be too small so that it cannot be tightened.

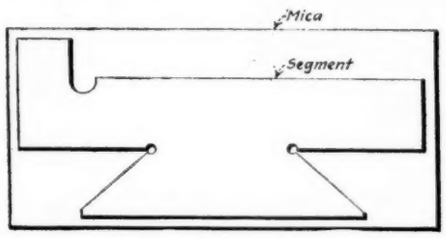


FIG. 4. INDICATED SIZE MICA SHOULD BE CUT

in either case the commutator cannot be tightened. Tightness of the commutator depends upon the pressure exerted by the tapered surface of the "V" rings on the inner tapered surfaces of the bars, forcing the latter to the center of the commutator.

Having selected the mica, cut it so that it will project about $\frac{1}{8}$ in. on each side of the segment, as shown in Fig. 4. If a quick job is required, a number of these

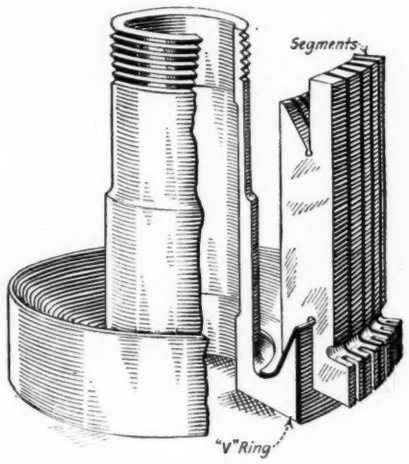


FIG. 5. ASSEMBLING SEGMENTS ON "V" RING

pieces can be clamped in a vise between two segments and sawed with a hacksaw to shape and finished with a fine file. A better method, but one requiring more time, is to shellac a piece of mica to each bar. The shellac may be air dried or baked at a low temperature, and the mica is then easily cut to exact shape with a sharp knife. In some repair shops it is the practice to keep the bars in their original position when reinsulating the com-

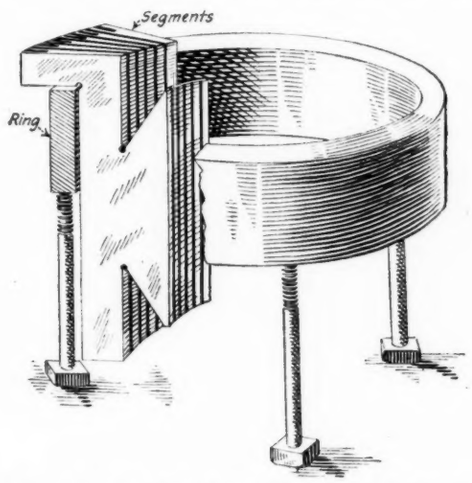


FIG. 6. ASSEMBLING SEGMENTS IN METAL RING

mutator, since all the bars may not be of the same length. Carelessness in this detail may result in a short bar being placed between two slightly long ones, which may cause loose segments.

While assembling the commutator, the bars and mica must be supported in some manner so that they can be arranged in a circle. This can generally be done by standing the segments on the "V" ring, Fig. 5, or supporting them by the risers in an iron ring as shown in Fig. 6. After arranging the bars in a circle, they should be tied and then clamped in an adjustable iron ring, such as in Fig. 7. This ring is used to draw the bars together on the circumference and hold them in a circle while baking and tightening the shell. Where adjustable iron rings are not available, the commutator may be wrapped at a number of points with about No. 8 copper wire, the ends of each turn twisted together to draw the commutator as tight as possible. In some cases the commutator is completely assembled before baking; however, it is better practice to bake the assembled bar and insulation before tightening the shell.

For heating, an oven should be used that will not permit the flame to come in contact with the mica. It is extremely important to apply the heat slowly, as an effect on the mica may be produced which will cause it to disintegrate and carbonize if oil should come in con-

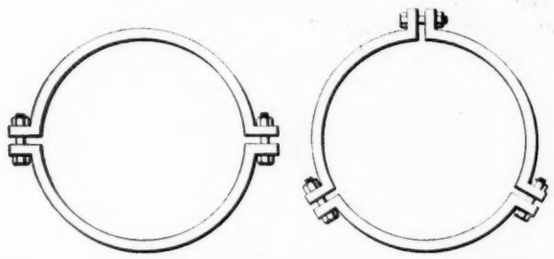


FIG. 7. TYPES OF CLAMPING RINGS FOR ASSEMBLING COMMUTATORS

tact with it while in operation. While the temperature is rising, the ring should be tightened as the mica softens. All small copper chips and particles of dirt must be removed from the inside of the bars, and a thin coat of shellac applied. The mica end rings are now put in and the shell drawn up tight, and the outside clamping rings removed and the commutator slowly heated. During this heating the bars may be gently tapped with a hammer and the holding bolts tightened.

After cooling, the commutator should be tested for ground from the different segments to the metal shell, and for short-circuits between adjacent segments. If found clear of defects, it is ready to be replaced on the armature shaft and turned. The centrifugal forces in the commutator while in service may cause it to loosen a little after a short time, therefore the bolts should again be drawn up after being operated for a period sufficient to allow the machine to attain operating temperature.

Pressure Between Brushes and Commutator

The pressure per square inch of brush surface on commutators recommended by manufacturers need not be considered in the selection of a brush, but should be observed in its application. The coefficient of friction, as well as the total friction loss, increases with increased spring tension. This would make it desirable to operate at the lowest possible tension. However, it is important that firm contact be maintained at all times, and in the case of non-abrasive brushes this contact should be rigid enough to give the brush a good polishing effect on the commutator.

It will be best in any case to consult the manufacturer's published data in regard to the grade of brush selected and apply the spring tension there recommended for that grade and class of service.

Modern European Tendencies in Power-Plant Design

By A. W. H. GRIEPE

WHEREAS in the past the policy in Europe was to build steam-power plants if possible at the point of utilization of the energy, the importance of a cheap coal supply has brought about a radical change, and now, in almost all cases, the determining factor in the location of new steam plants is proximity to the mines, with due consideration to the availability of cooling water. Fortunately, the collieries in France, Belgium, Germany and England almost always coincide with the large industrial centers where there is the greatest demand for power.

The European tendency is now to supply the large cities at high voltage from large generating stations near the mines, and gradually to shut down the small, inefficient local plants. A noticeable feature of the latest stations built near large cities is the enormous increase in coal-storage facilities, capacity up to 250,000 tons having been provided in a few cases, in order to avoid interruption of service through strikes or other causes interfering with the coal supply.

Modifications in Boiler Proportions

Since the almost general adoption of the steam turbine as a prime mover for large steam-electric plants, the floor space required for the boiler room has grown out of all proportion to that of the turbine room, and there has been a marked attempt to modify the design of boilers so as to reduce the floor space, by decreasing the base and increasing the height. This made higher boiler rooms necessary and larger coal bunkers possible, the latter being a great advantage in handling low-grade fuels.

Coal-handling apparatus is normally of the bucket- or belt-conveyor type, with automatic scales installed at the points of delivery. In a few cases traveling coal scales have been provided that may be connected to coal chutes from the bunkers to the stoker hoppers. Coal bunkers are usually of parabolic shape, suspended from columns. Coal is sometimes stored in silos and carried to the top of the bunkers by inclined drag chains.

Ash is handled in many different ways, and it cannot be said that general practice favors one method rather than another. Air-suction ash conveyors are gaining ground, however. The clinkers are crushed by a motor-driven crusher as they leave the ash hopper. This is considered by the writer preferable to providing a separate crusher for each stoker unit and crushing the clinker before it reaches the ash hopper, for the crusher is more exposed to damage in the latter case.

Types of Steam Boilers in Use

The latest types of European boilers operate at efficiencies reaching 83 per cent or higher. The new types of water-tube boilers evolved have vertical or inclined tubes. The best-known types are: Garbe, Burkhardt, Steinmueller, German Babcock & Wilcox, Stirling, Niclauses, British Babcock & Wilcox, Belleville, Glogner, Toci, etc.

The most advanced type seemed to be the Burkhardt. The setting of this boiler is remarkable in so far as the losses due to radiation are reduced to a low degree. The furnace is in the middle of the setting, protected on three sides by interior walls; the hot flue gases after passing through the tubes, are discharged around the furnace into a compartment formed by the interior walls of the furnace and the exterior walls of the setting. One section of this compartment contains the high-pressure economizer. Part of the hot gas is diverted at the second pass, and forced through the other section of this chamber containing the superheaters. Registers placed in the interior division wall, for the purpose of varying the volume of furnace gases diverted to the superheaters, allow a close regulation of the temperature of the steam. The hot gases leave this compartment at about 800 deg. F., flow back into the last pass of the boiler, and from there into the economizer compartment with the remainder of the gases.

Boiler Tubes and Superheaters

In many types of boilers straight tubes are being used instead of curved, as in the Stirling boilers, and it is stated that the expansion of the tubes is taken care of by the position of the drums. Many manufacturers make the three rows of tubes nearest the grate of heavier material, to avoid bursting and bagging, and consider the loss of efficiency due to the heavier tube wall of less importance than the constant trouble of changing tubes.

All boilers are furnished with superheaters, and automatic control is provided to produce an even temperature of superheat. The superheaters are made up of wrought-iron pipe and steel headers. To avoid impurities being carried over into the superheater, a drum is installed between the saturated steam outlet and the superheater, to allow the sediment to settle in the drum, by the reduction of the steam velocity. This installation may be found on all types except the Babcock & Wilcox.

Economizers Compulsory

The demand for greater efficiency of boilers has made the installation of economizers compulsory in practically all installations. The efficiencies are increased from 5 to 10 per cent in all cases and the temperature of the flue gases entering the stack has been reduced in many instances to 300 deg. F. The economizers can be classed as follows: (1) Low-pressure economizer with cast-iron pipe (Green type); (2) low-pressure economizer with wrought-iron or steel pipe; (3) high-pressure economizer with cast-iron pipe; (4) high-pressure economizer with wrought-iron or steel pipe. Types 1 and 4 are generally installed in European plants, with isolated cases of types 2 and 3. The objection raised against type 1—that is, scraper installation, leakage, large floor space necessary, etc.—was one of the reasons for the development of type 4, especially in cases where the floor space is limited.

The general arrangement of installations favors an individual economizer for each boiler without a bypass. If a number of boilers are connected to a common economizer, a bypass is installed to avoid a complete breakdown of the steam supply. The new design of boilers

uses the high-pressure economizer, type 4, made part of the boiler and installed in the setting. This type, now mostly installed in European plants, has many advantages over the low-pressure type; it gives higher water temperatures, substitutes soot blowers for scrapers, reduces the loss due to radiation, and decreases the loss of draft. The disadvantage of the greater susceptibility to corrosion of steel pipes can be partly offset by installing filters, etc., but apparently the corrosion is not so excessive in high-pressure steel-tube as in low-pressure steel-tube economizers. Possibly this is due to the higher pressure and temperature. A combination of high-pressure steel-tube economizers and low-pressure cast-iron pipe economizers has been tried, but results have not warranted the increased first cost and expense of operation.

Types of Stokers Used

Nearly all boilers are now being provided with stokers, and the general tendency is to place the stoker inside the setting, thus obviating the use of the extension furnace and saving floor space. This results in better heat radiation directly from the fuel bed to the tubes, but requires higher boilers. Large boilers have either traveling-grate or chain-grate stokers, underfeed or Murphy type. Taylor-type stokers are seldom installed on the Continent, but frequently in England. Small boilers are fired by the small throwing-arm type of stokers. In all stoker installations an air shield or dumping plate is installed on the end of the grate near the bridge wall in order to prevent the air from leaking in between the bridge wall and the fuel bed. This shield, operated from the outside, retains the clinkers of the grate and protects the bridge wall until it becomes necessary to dump the clinkers. The furnace walls and bridge walls, where the shield is lacking, are protected by water-backs. Old boiler tubes through which air is circulated have been tried for this purpose, but with slight success, as it is apparently impossible to carry the heat away fast enough to prevent buckling. The stokers are operated in the majority of installations by electric motors. Forced-draft connections are the same as used in America.

A new type of chain-grate stoker has an additional motion besides the horizontal movement of the link; every other link is alternately raised and lowered during its horizontal travel. This prevents the clinkers from adhering to the links.

Cinder and Soot Disposal

The deposit of cinders and soot is increased to a considerable degree when burning low-grade fuel, and to overcome this, large hoppers and pockets are provided wherever the direction of the flow of the gases changes. These pockets can be cleaned while the boilers are in operation; soot blowers are installed in nearly all plants. In the Burkhardt boiler, soot and cinders are removed by a screw conveyor.

The disposal of ashes and cinders is not a serious matter in European countries, as they are utilized in many ways foreign to American practice. Manufacturing concrete blocks and filling in country roads are some instances of their utilization, this being made possible by cheap water transportation.

Preheating of the Air

In a few cases the heat in the ash hopper is used to preheat the air for the forced draft, ducts passing through the hopper and connection to the suction inlet of the forced-draft blower. The most advanced installation for heating air is in the Northampton Electric and Power Co.'s plant, Northampton, England. The warm air from the generator passes through an air duct located in the flue, entering the blower at a temperature of 230 deg. F.

Flues and Stacks

Long flues and high stacks are seldom found in the modern plants. They have been replaced by individual stacks for a single or small group of boilers. The Prat or flaring stack has been installed in a majority of cases. The scarcity of sheet metal, on account of the war, was possibly the deciding factor in the adoption of the Prat system, as these stacks require only about one-eighth the material used by the average stack. Other advantages are that the blowers do not handle the hot flue gases; with a combination of forced draft under the stokers and the Prat system, all draft conditions can be taken care of.

Many types of draft regulators are installed, based on the intensity of the draft, but the only scientific regulator is one type that is actuated by the CO_2 content of the flue gases. This apparatus operates on the chemical electric principle.

Low-Grade Fuels Used

Low-grade fuels, culm, mine refuse, lignite, peat, and of late coke, have been used and good results obtained in all cases where the proper apparatus for testing and recording has been installed. Most of the European operating engineers agree that the boiler-room force is willing to make proper use of the apparatus to reduce the coal consumption, provided the necessary controlling instruments are installed and a bonus system is established which benefits the employer and employee alike.

Good results have also been obtained with gas coke. For hand-fired boilers no trouble was encountered, and for stoker-fired boilers the same installation as for lignite proved to be the most advantageous.

Coal tar mixed with coal dust has been used with success in the proportions of one part coal tar and ten of coal. Peat has been used experimentally, and the tendency in research has been in the direction of reducing the moisture content of the peat. Powdered coal is used in many plants and the results obtained are satisfactory.

Few new types of oil furnaces are to be found. One new type is developed in Roumania, giving good results with crude oil of a paraffine base. Larger developments of oil furnaces may be found in connection with metallurgical furnaces. Gas-furnace improvements are found only in connection with blast-furnace and coke-oven gas; 78 to 80 per cent efficiency has been obtained with the former, and 75 to 80 per cent with the latter.

Bone-Schnabel Surface Combustion Process[1]

The revival of the surface-combustion phenomenon, made in 1914 simultaneously in England by Prof. Bone and in Germany by Schnabel, has been advanced beyond the experimental stage and is now in actual operation. This process consists of burning gaseous fuel and air, in practically theoretical proportions for perfect combustion, in a jet impinging against a surface of refractory material. Very high temperatures and complete combustion are attained, also high rates of heat transfer through the boiler walls by radiation. The boiler in-

[1] See *Power*, Vol. 42, pp. 787 and 855, and Vol. 45, p. 225.

stallations in Germany using this type of furnace have shown an efficiency of 93 per cent with an economizer and 87.8 per cent without an economizer. From these results it would seem advisable to build a test furnace under our oil- and gas-fired boilers. With increasing boiler pressures, superheat and combustion rates, the Bone-Schnabel furnaces may well prove to be the best.

Higher Steam Pressure and Superheat Advocated

The war has forced many plants to overhaul their equipment to increase the efficiency of the boiler plant, and in many cases new boilers have been installed with higher efficiency guarantees.

Higher steam pressure and high superheat are advocated as one way of increasing boiler efficiency. The only plant using exceptionally high steam pressure and superheat is at Rugby, England. This plant operates at a steam pressure of about 370 lb. per sq.in. and a total steam temperature of nearly 700 deg. F. Over 500 lb. per sq.in. had been the proposed pressure, but it was considered advisable to lower this to 370.

There seems to be no trouble in making high-pressure boilers as long as each individual section is of a circular cross-section. Boilers with large flat water boxes are not suitable for high pressures. Experimental boilers have been installed operating at pressures up to 40 atmospheres, or nearly 600 lb. per sq.in., but as a standard installation 25 atmospheres, or 370 lb., and 700 deg. F. steam temperature seem to be the limit at present.

Feed Water and Corrosion of Boiler and Economizer Tubes

The supply of pure feed water is solved in many cases by distilling the water rather than by chemical treatment. Simplicity is one of the main advantages of this process, and as no chemicals are used, no skilled labor is needed to operate it.

The corrosion of feed piping and boiler and economizer tubes is one of the most serious troubles in power plants. Many investigations have been made to find the cause. Where reciprocating engines are used, the corrosion is partly due to the acid formed by the oil, but even in power plants exclusively using turbines, the trouble occurs frequently. Investigations have shown that it is due to electrolysis, carbonic acid, ammonia, air, oxygen contained in air, salt, lime, etc. The most exhaustive study has been made by the *Vereinigung der Elektrizitats Werke*,[2] Germany. It has been found that the condensate return from turbines readily absorbs oxygen from the air contained in the steam or from the outside air. This oxidized water attacks the wrought-iron or steel pipes, pitting the pipe walls. Cast-iron pipes, owing to their high carbon content, are not attacked.

Low-pressure economizers with cast-iron pipes or high-pressure economizers with steel pipes and cast-steel headers, are now installed in nearly all plants to heat the water. Automatic feed-water regulators are installed in all plants excepting the temporary plants connected with war work. Open feed-water heaters are generally used, while closed and high-pressure feed-water heaters are used in isolated cases only.

All plants favor the arrangement of the axis of the turbine room perpendicular to the axis of the boiler room; that is, a row of boilers for each unit and the main steam pipes cross-connected near the division wall of boiler and turbine room. This layout is said to minimize the danger of interruptions during construction incident to future extensions of the plant. In most cases the auxiliaries are placed in the turbine-room basement and all other pumping units collected in a separate space in the basement. Condensers are placed below the turbine with their axis at 90 deg. to that of the unit. Large wells are provided in the operating floor to facilitate the removal and replacement of machinery by the traveling crane. The operating floor is often made up of removable floor plates, either cast-iron or diamond-steel plates.

Only Horizontal Type of Turbines Used

Horizontal types of turbines are installed in all cases. The vertical type seems to be obsolete. In large plants on the Continent, 25,000-kw. units are common while units up to 55,000-kw. have been operating since 1914. Exhaust and mixed-pressure turbines are practically always of the double-flow type. The efficiencies of turbines are a little better than have been obtained in America.

Surface condensers are installed in most plants, and they are being developed mainly with a view to affording uninterrupted service. To this effect, some condensers are divided into two compartments, so that in case of a breakdown one section only has to be cut off. The circulating pumps are in duplicate, each 75 per cent of the capacity necessary to run the condenser, so that each pump is large enough to supply water during a breakdown, of course at a reduced vacuum. Steam jets instead of water jets and dry-vacuum pumps are favored in the new plants. Condensate pumps of the centrifugal type are motor-driven. The auxiliaries are either steam or electric-motor driven and a standard installation has not yet been evolved.

When steam drive is used, the complete unit, including main unit and auxiliaries, is supplied from one steam header. This arrangement, combined with the fact that each generating unit has its own row of boilers, makes each unit an independent power plant, so to speak.

Many new devices have been developed to clean condenser tubes without putting the condenser out of service. One apparatus, apparently the simplest, shuts off a number of tubes and forces water at a high velocity through them, thus forcing out the sediment. Hydrochloric acid has been suggested as one means of cleaning, also the sand blast.

Cooling-Water Supply

The cooling-water supply is not as troublesome as in in this country, for an abundant supply is easily obtainable. New installations are equipped with the typical arrangement used in America, revolving screen, etc. One installation in England shows a radical departure by installing a circular revolving screen in the form of a disc. This installation is simple, clean and efficient, as the débris is thrown clear of the screen.

Cooling-tower installations are more numerous than spray ponds.

Air cooling of generators is accomplished after the usual practice, except in a few instances. In one installation the air intake for all units is combined in a separate building, and only one air purifier is used for all the generators in the plant.

[2]An association similar to the N. E. L. A.

Fisher Multiple-Disc Valve

A novel design of valve has recently been developed, known as the Fisher Cube Valve. The main interest of design is that there are four disc and four seating surfaces. The seat is made with a large face to accommodate the four diameters of the valve discs, which in the 1¼-in. valve are 1⅝, 1¼, 2⅛ and 2½ in. respectively.

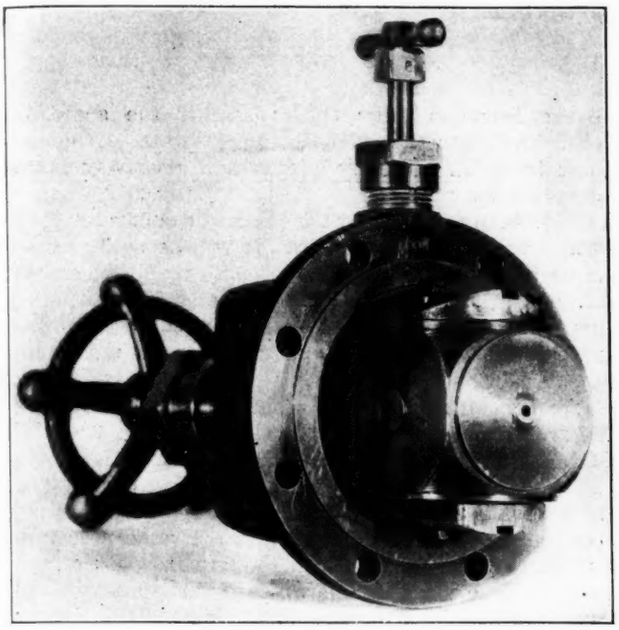


FIG. 1. VALVE BONNET AND DISC CUBE

The valve body is made in two sections, Figs. 1 and 2, the seat and pipe connections being contained in the lower half, which permits of removing the working parts without interfering with the connections. In the upper portion there is a cube-shaped revolving disc head having four discs of different sizes. This cube revolves on two pinions having a bearing in a yoke piece that is attached to the valve stem by a retaining nut and permits the stem to turn, the threads on the stem moving the cube holder in or out to open or close the valve.

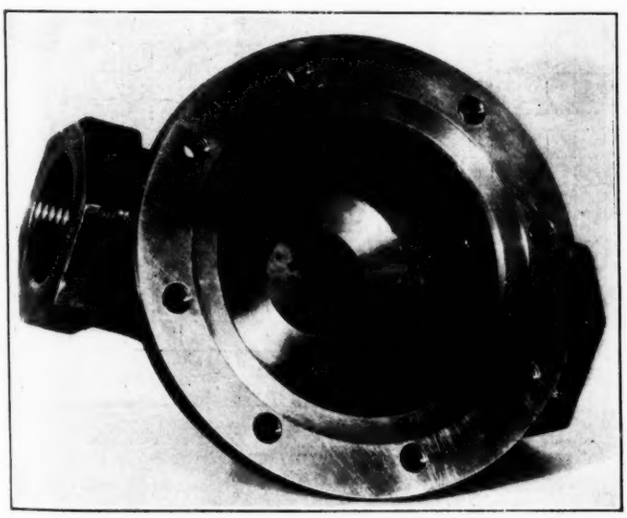


FIG. 2. SHOWING VALVE SEAT

One of the yoke pinions is hollow, and an oblong locking key is fitted in it and is held in the locked position by a spring, thus preventing the disc from turning while the valve is in service. On the top portion of the valve body is a stuffing nut through which a key stem passes, and is so located that when the valve stem is screwed to the wide open position, the key stem can be pushed in, and by forcing it against its spring, the cube can be revolved to bring the next size of disc to a seating position. In this way the cube can be turned until all four disc surfaces have been used. The two smaller sizes of discs are made so that they can be refaced several times before being unfit for further service. The cube can be turned from one seating position to another, only while the valve is in the open position and while it is in use. The valve cannot be closed while the cube is in any other than its seating position, Fig. 3, and numbers stamped on the handle of the key stem designate which disc is in the seating position.

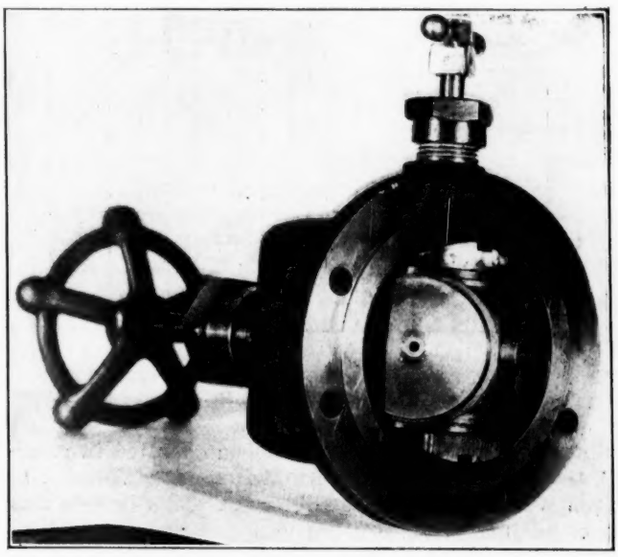


FIG. 3. VALVE CANNOT BE CLOSED WITH CUBE AS SHOWN

As the discs are of four diameters and as the seat is so proportioned as to make a bearing surface for the smallest to the largest disc, a new seat is provided for each adjustment of the disc cube. The device is manufactured by the Fisher Compounded Valve Co., Providence, R. I.

An adjustable-speed motor is one whose speed can be adjusted to specific values within a given range, and the speed of the motor will remain practically constant from no load to full load of the motor. A shunt motor with field control is a machine of this type. With a variable-speed motor the speed varies inversely as the load, but is constant when adjusted for some given load. Any direct-current motor with armature control is a machine of this type. As long as the load remains constant the speed remains constant, but if the load is increased the speed will decrease, and if the load is decreased the speed increases.

Operating Pumps or Fans in Parallel

A Discussion of the Problems Encountered in Parallel Operation of Centrifugal Pumps with an Explanation of Why Pumps Must Have Correct Characteristics

By J. C. HOBBS*

CENTRIFUGAL fans and pumps have become such important items in the equipment of modern power plants that careful consideration of certain practical phases of their performance is justified. Almost any fan or pump will perform satisfactorily if operated alone. When two pumps discharge into the same distribution system, as they must when operated in parallel, then to be successful, certain fundamentals must be given attention or trouble will occur. This trouble may be either unsatisfactory performance, such as lack of capacity, or, under certain conditions, may take the form of wrecking the apparatus.

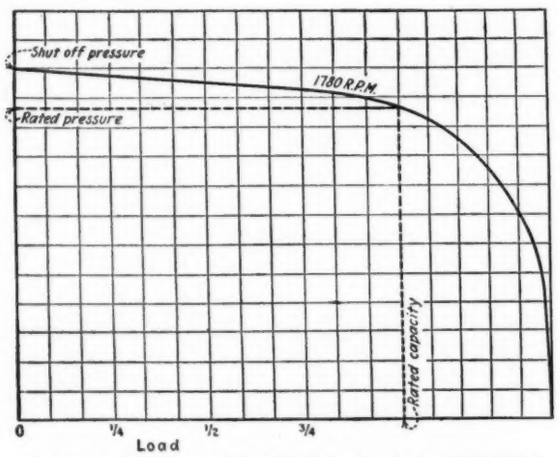


FIG. 1. TYPICAL PRESSURE CHARACTERISTIC OF FAN OR PUMP

Fans or pumps should have proper operating characteristics, and the method of regulation must be right. By the word "characteristics" is meant the inter-relations between pressure produced, output, horsepower and speed, expressed usually in the form of curves. The pressure characteristic of a pump or fan is analogous to the voltage characteristic of the direct-current electric generator, and in many ways the performances of pumps or fans in parallel are similar to those of direct-current generators because the same fundamentals apply to both.

Fig. 1 shows the typical pressure characteristic of a pump or fan. A pump having such a characteristic would give satisfactory operation in parallel, other conditions being right. From the illustration it will be noticed that there are three variables to be considered: First, pressure; second, speed (r.p.m. times impeller circumference), and third, capacity or output. An increase in speed results in a proportionate increase in capacity up to fixed limits. An increase in speed also increases the pressure produced, but at a faster rate. Within certain limits the pressure varies as the square of the speed. To illustrate, if the speed is doubled, the pressure increases four times; and if the speed is tripled, the pressure increases nine times. A small change in speed therefore produces a relatively large change of pressure.

In Fig. 2 the curves show the effect of changes in speed on the pressure characteristics. It will be noticed that it is necessary to change the speed to maintain a constant pressure at all loads. For successful operation it is important that the characteristic curves have a downward slope at all points from zero load to the maximum output. Reference to the same illustration will show that for constant pressure the speed decreases continuously from full load back to zero load.

If this characteristic forms a hump such as is shown in Fig. 3, there will be two outputs having exactly the same pressure and speed. If two pumps are operated in parallel and discharging against the same pressure, then one of them might be on the upward part of the curve and the other on the downward part, thus causing an unequal distribution of load. This condition is not so serious where steam-turbine drives are used, but with motor drives where the speed is practically constant, unsatisfactory performance will occur.

With a steam-turbine drive there is the possibility of one of the pumps being "backed off the line." When this occurs, there is danger of the pump becoming air-bound, and the rotor, in rubbing against the dry seal rings, will likely cause damage. Instances have occured where parts of the bronze impellers and seal rings have melted, owing to the large input of power from the turbine shaft being converted into heat through friction.

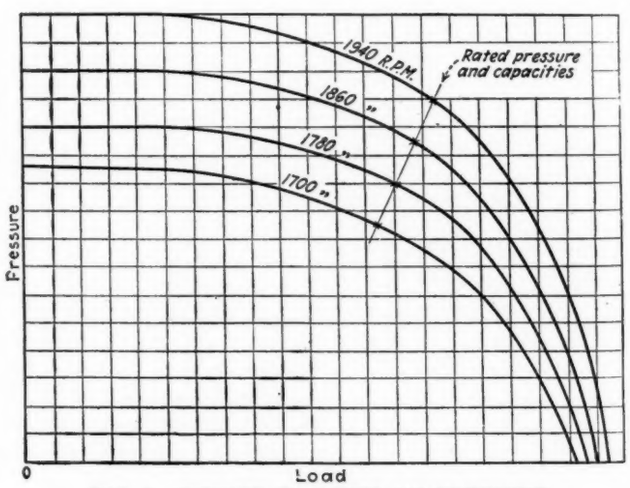


FIG. 2. EFFECT OF SPEED ON PRESSURE CHARACTERISTICS

Usually, pumps are operated at approximately constant speed. The variation occurring when pumps are driven by constant-speed motors is due to the "slippage" which must always be expected. When standard motors do the driving, the slippage or decreasing speed from

*Manager, Allegheny County Steam Heating Co., Pittsburgh, Pa.

no load to full load amounts to only 2 or 3 per cent. Variable-speed motors can be and are sometimes used, but such installations are comparatively few, owing to the higher first cost, lower average efficiency and greater complication. Even a 2 or 3 per cent decrease in speed, due to slippage, will produce from 4 to 9 per cent change in the discharge pressure. Turbine-driven pumps will maintain practically constant pressure, outside of the slight variation required to operate the pressure-control valve from wide open to tight shut.

It is not desirable to try to regulate the pressure between too narrow limits, because hunting action of the governor or pressure-control valve will occur. The desirable form of characteristic is one in which the discharge pressure drops slowly from zero load up to a point beyond the full capacity rating and then drops off suddenly. A "flat characteristic" of this sort requires less change in speed to take care of the variable output, and results in a more constant discharge pressure. The reason the curve should drop abruptly beyond the maximum capacity, is to prevent overloading of the driving motor.

The horsepower required to drive any pump or fan depends on the quantity handled and the pressure

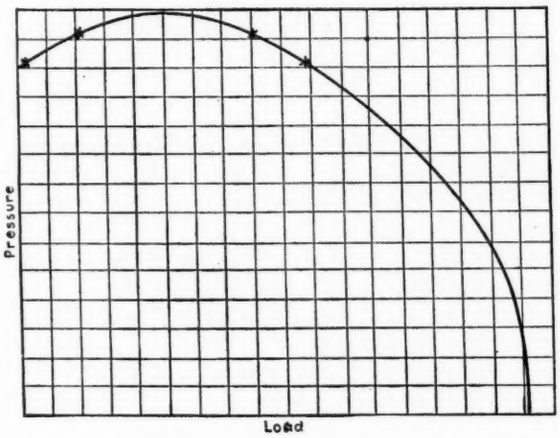


FIG. 3. EFFECT OF HUMP IN PRESSURE CURVE

against which it is discharged. If the pump is so constructed that the discharge pressure will drop when the quantities become excessive, then the product of pressure and quantity at any point is limited and there is less danger of burning out the motor.

Engineers who are familiar with direct-current generators will recognize similarities which exist between the direct-current generator, of the shunt type particularly, and fans or pumps. The compound type of characteristic can be obtained for pumps, but on account of the impossibility of installing any equalizing bars or anything else to serve the same function, such pumps can be operated only as independent units.

Fig. 4 shows the general form of the curves obtained from the three different shapes of impeller blades. It will be noticed that the upward curve is produced by a forwardly curved impeller blade, the horizontal by radial blades and the dropping curve by backwardly curved blades. Each type of blade has its particular field and the detailed characteristics, peculiarities and limitations can best be learned by consulting a specialist in that field. It might be mentioned that a new type of impeller having both the forward and backward curves has been designed for centrifugal fan work.

The possibility of damage to a pump on account of becoming steam or air bound has been reduced, if not eliminated, by provisions indicated in Fig. 5. This sketch shows a scheme of piping which can be used in connection with open heaters to prevent the first stage from becoming steambound. This arrangement should

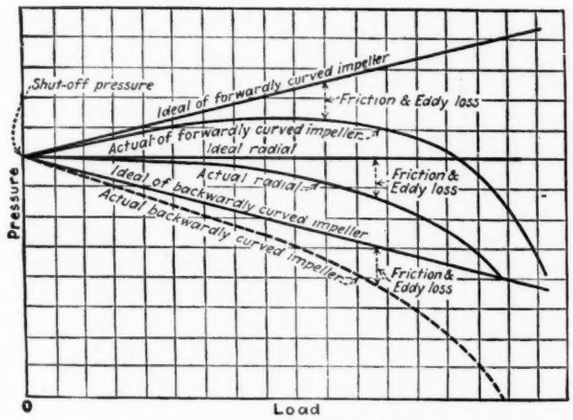


FIG. 4. GENERAL FORM OF PRESSURE CURVES FROM DIFFERENT TYPES OF IMPELLER BLADE

be installed on each pump operated in parallel, whether it has the proper characteristics or not, because a small amount of trouble with the pressure governor is liable at any time to divide the load unequally and one of the pumps may cease to discharge water when the total load becomes light.

In this same connection it is quite desirable whenever a turbine is used to drive the pump, to install on it an inlet pressure gage to show the steam pressure between the governor and the nozzles. The pressure indicated by such a gage is a good index to the load being carried by the turbine, which in turn is a fairly good indication of the output of the pump. Whenever two pumping units of the same capacity and characteristics are operated in parallel, the inlet pressure gages will show the division of the load.

Whenever practical some kind of a metering arrangement on the discharge of the pump is desirable. It is

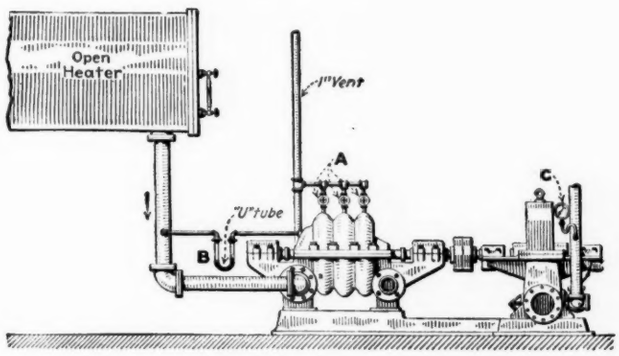


FIG. 5. CONNECTIONS TO PREVENT PUMPS BECOMING STEAMBOUND

doubtful whether the installation of a venturi meter or other form of water meter is justified, but in some cases a U-tube can be installed, as in Fig. 5, between the suction header and the inlet chamber on the pump, in such a way as to use the friction head through the suction piping to give an approximate indication of the flow.

Such a meter, of course, is not intended to give accurate indications of the exact quantities flowing, but merely to show, relatively, the load on the different pumps.

Fig. 6 compares roughly the horsepower curves that may be expected from forwardly and backwardly curved forms of impeller blades. This illustration is intended

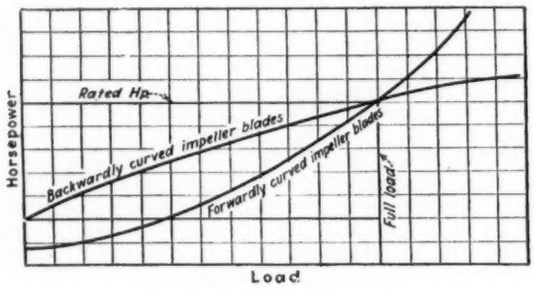


FIG. 6. HORSEPOWER CHARACTERISTICS OF IMPELLER BLADES

only to give an approximate conception of the power requirements. There are so many factors involved that it is impossible to cover them all in limited space, and primarily this is the field of the pump designer.

Two Governors Regulate Hydraulic Unit

A high degree of flexibility and a flat efficiency curve under varying load conditions were attained in the hydraulic unit recently installed in the Newhalem Creek hydro-electric plant. This plant supplies power for construction purposes on the Skagit project, which is being carried out by the City of Seattle about 100 miles north of that city on the Skagit River.

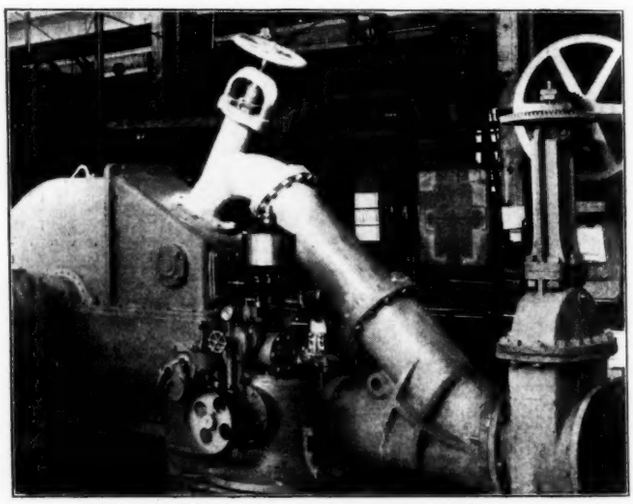
In selecting the hydraulic unit best suited to the conditions at this plant, both impulse and reaction types were considered. The manufacturer would guarantee 84 per cent efficiency on a reaction turbine and only 79 per cent on an impulse wheel. However, the impulse type was chosen because it was believed to give greater assurance of continuous service. This was particularly important as there was to be only one unit in the installation and no other plants on the system. Features of the impulse type that were considered of particular advantage in this plant were the possibility of dividing the prime mover into two parts, the elimination of wear on gates, and the elimination of the thrust problem.

The plant has a single 3,000-hp. unit consisting of a generator driven by two waterwheels, one on each end of the extended main shaft. The runners are of the impulse type and operate under a head of 510 ft. at 450 r.p.m. The desired degree of control was secured by the use of two independent governors, one for each side of the unit. One of these is adjusted for a narrow speed range, while the other is set to take care of the heavy load swings. Each governor has its own oil-pressure pump, pressure tank and sump, the governor head and pump being independently belt-driven from the waterwheel shaft.

The subdivision of the prime mover into two parts makes it possible to shut down either half separately, thus operating the electrical unit at half load with hydraulic efficiency as good as for full load. This is expected to be a great advantage in times of light load requirements or limited water supply. It is also possible to make adjustments or replacements of parts on either side of the unit while the other half is in service, thus providing more than the usual insurance against complete shut-down and interruption of service. With two governors on the unit, either one can be taken out of service and adjusted or repaired without decreasing the output of the plant, all load fluctuations up to 50 per cent of capacity being taken care of meantime by the remaining governor.

By a sensitive adjustment on one of the governors and a wider speed range on the other, compensations for all small load fluctuations are made by the first governor, while large changes in demand are handled by the second. Thus a closer and more sensitive speed regulation is obtained than would be feasible if the entire unit were being controlled by a single governor, because any tendency toward hunting, which might occur in a single governor with an over-sensitive adjustment, is prevented by the action of the second and more sluggish governor. This arrangement makes it possible to operate a single-unit plant on a basis similar to that of a well-balanced power system in which the sensitive governing is taken care of on one unit while other units are adjusted to handle only the heavy load variations.

Speed regulation in the Newhalem plant could have been effected by direct governor control of needles in the nozzles or by use of a diverting jet of either deflector or sleeve type. The needle type of control would have made



ARRANGEMENT OF ONE-HALF OF OVERHUNG UNIT, NEWHALEM PLANT

it possible to economize on the use of water, but as no provision for storage was made in this development, there was no advantage in saving water. A sleeve-type deflector was therefore selected, designed to avoid any loss of efficiency in the jet and to give full protection from pressure rises in the penstock.

As this unit is rarely if ever to be operated at less than 50 per cent of its rating, it was considered permissible to omit the hand-operated needle on the lower nozzle of each runner, thus avoiding the losses in efficiency that such needles would have involved. The upper nozzles, however, are provided with hand-operated needles so either runner can be cut down to half load without disturbing the governor setting.

The hydraulic equipment at the Newhalem plant was supplied by the Pelton Water Wheel Co.

Lubrication—Petroleum Production

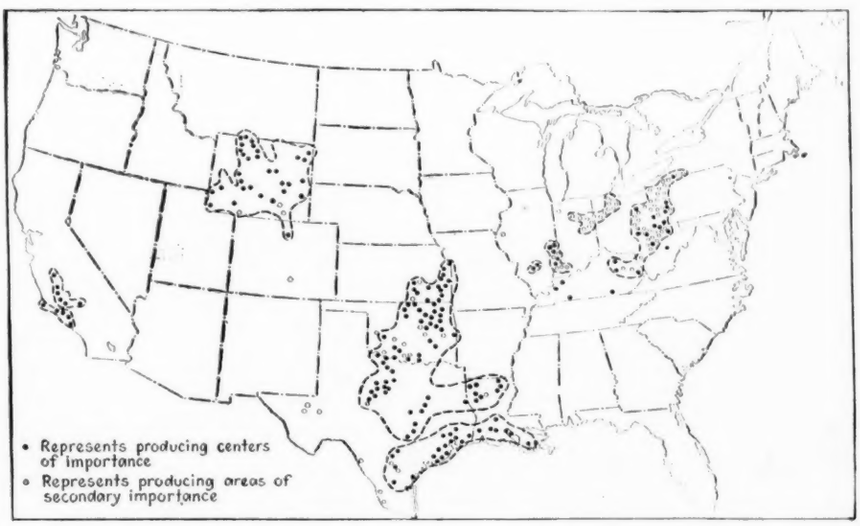
BY W. F. OSBORNE

THE greater portion of the crude petroleum produced in the United States is secured from several fairly well defined localities, a small percentage being produced from scattered wells in other parts of the country. The accompanying map, taken from the United States Geological Survey, shows the location of the principal fields, from which the production for June, 1921, was as follows:

TABLE I. FIELD SHIPMENTS

Field	Barrels	Per Cent of Total
Midcontinent	22,075,000	54.7
California	10,120,000	25.0
Gulf Coast	2,594,000	6.4
Appalachian	2,525,000	6.3
Rocky Mountain	1,980,000	4.9
Illinois-Indiana	895,000	2.2
Lima-Indiana	216,000	0.5
	40,405,000	

These crudes vary a great deal in their characteristics, particularly those found in the mid-continent field. The Appalachian field, comprising Pennsylvania, New York, West Virginia, Kentucky and Eastern Ohio, produces crudes that contain a large percentage of light gravity oils of the paraffin series. The crudes are high in gravity, contain little sulphur, and when refined yield a considerable amount of gasoline, kerosene, light- and medium-bodied lubricating oils, steam-cylinder oils and paraffin wax. On account of their comparative freedom from sulphur they are inexpensive to refine and command a high price.



PRINCIPAL PETROLEUM FIELDS IN THE UNITED STATES

The Gulf Coast and California crudes contain a large percentage of heavy hydrocarbons of the naphthene series from which they get their name. They are low in gravity, contain a fair amount of gasoline, a large percentage of medium and heavy lubricating oils, fuel oils and asphalt. They frequently contain considerable quantities of sulphur compounds, which increase the cost of the refining and lower the market value of the crude.

All of the various types of crudes are separated into many finished products which vary with the crude and the nature of the refining process through which the oil is passed. The general classes of these products are: Gas, gasoline, naphtha, kerosene, gas oil, fuel oil, lubricating oil, road oil, asphalt, coke and paraffin wax. In each class there are, of course, many grades which vary in the number and percentage of various hydrocarbons and impurities. The percentage of any particular class can also be changed slightly by regulating the refining process, should it be found desirable to increase the amount of any one product. This has been done in the case of gasoline during the last few years, a larger yield being secured by means of the "cracking" processes.

TABLE II. LUBRICATING-OIL PRODUCTION

Field	June, 1921 Barrels	Per Cent of Total
Midcontinent	820,500	54.7
California	375,000	25.0
Gulf Coast	96,000	6.4
Appalachian	94,500	6.3
Rocky Mountain	73,500	4.9
Illinois-Indiana	33,000	2.2
Lima-Indiana	7,500	0.5

On the basis of the percentage shown in Table I, the lubricating oil refined from the crudes produced from the various fields can be estimated as shown in Table II. The actual production will of course vary from month to month, and the percentages produced from each field will be governed, to a certain extent, by the marketing requirements of the refiners. From these figures it will be seen that the greater portion of our lubricating oils must necessarily come from the Midcontinent fields. Otherwise it would be quite impossible to meet the demand for lubricating oils. Engineers and others interested in the preparation of specifications for the purchase of lubricating oils will be wise in considering carefully whether the specifications under which they are buying are so drawn as to limit the lubricant to a narrow field. A limitation always results in an increased cost for the products that meet the specification if a large number of buyers follow the same specification, as it eliminates from competition many otherwise wholly desirable lubricants made from other crudes. The vast supply of lubricants available from the Midcontinent fields cannot be ignored in preparing specifications if it is desired to secure oils not subjected to artificially increased prices. Any specifications that might be drawn should be made so broad as to permit the inclusion of any type of lubricating oil that will give satisfactory service under practical operating conditions regardless of the crude from which it might be made. The belief held by many engineers that only Pennsylvania crude is suitable for lubricating oils is far from being true, asphaltic base oils giving equally good results.

Modern Steam-Engine Indicators

Following a discussion of the advantages of the indicator, this article, the second of the series, briefly describes a number of the indicators in general use. Follow this entire series of indicator articles and so avoid missing vital parts.

THE Richards indicator has been replaced by more improved instruments possessing light weight and better workmanship, and it is seldom that a Richards is found save in mechanical exhibits at various colleges.

Modern indicators followed in general the design brought out by Richards and until the last few years were all made with an inside spring, as shown in Fig. 1. Here the working barrel *A* is surrounded by the housing *C*, the space between the two acting as a steam jacket, with the idea of avoiding distortions of the barrel from uneven temperatures. The lower end of the barrel is free to accommodate itself to change due to varying steam temperatures. The piston *B* works inside the barrel and is provided with a spring, the resistance of which causes the piston travel to be proportionate to the steam pressure under the piston. The upper end of the spring is attached to the indicator cap. The

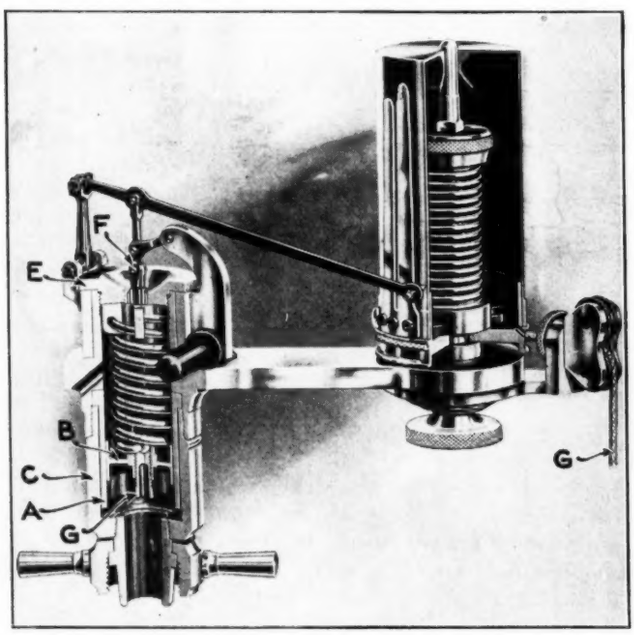


FIG. 1. TYPICAL INSIDE-SPRING INDICATOR

piston is provided with a piston rod which carries at its upper end the swivel head *F* to which is attached the pencil linkage as shown. The drum, about which is wrapped the paper card, is carried on an arm projecting from the indicator housing. The cord *G* is attached to the engine reducing motion, and its pull is opposed by the tension of the drum spring. This arrangement insures the cord being held taut at all times, and when the cord on the out stroke of the engine rotates the drum, the spring tension brings the drum back to its original position on the return-stroke of the engine.

As long as steam pressures and temperatures were not high, the inside type of indicator proved to be perfectly satisfactory. Under modern conditions with 150

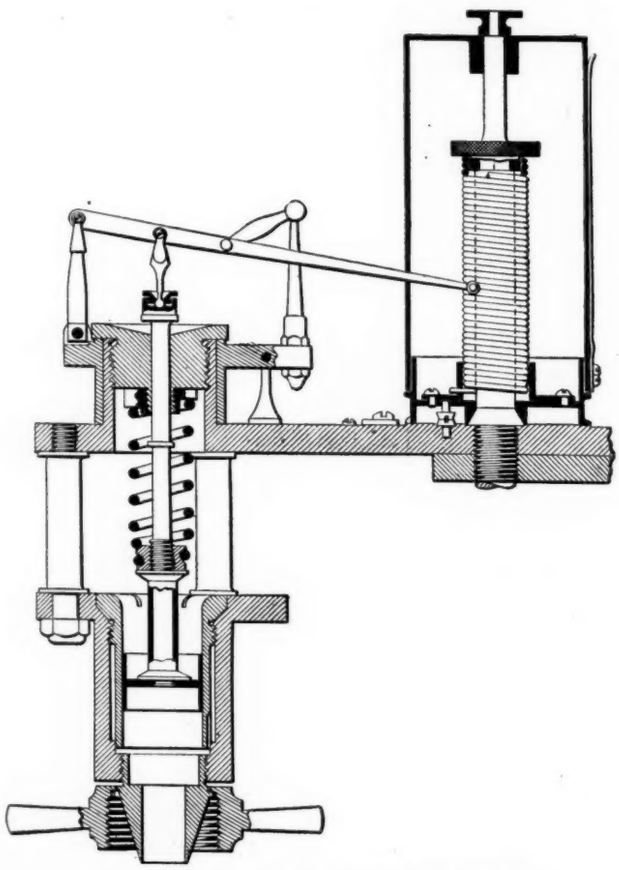


FIG. 2. TRILL STEAM-ENGINE INDICATOR

to 225 lb. steam pressure, often superheated, the location of the spring within the indicator barrel was unfavorable. The high temperatures altered the characteristics of the spring, giving unreliable diagrams. The spring was placed on top of the indicator, away from danger of excessive temperature changes, and the majority of instruments manufactured in recent years are of this type.

The Trill Indicator

The body of the Trill indicator, Fig. 2, is of brass, while the cylinder barrel is of bronze and is held in the body by a screw joint. The space between the barrel and housing acts as a steam jacket. The cross-sectional area of the piston used for standard steam pressure is one-half inch. For oil and gas-engine work the barrel and piston are removed and a high-pressure barrel and piston of one-quarter inch cross-section area are used.

The piston is made of brass and is provided with two small grooves to retain water and oil for sealing purposes. The piston rod is of tool steel and is provided with a lug onto which the piston spring is screwed

and with the piston weighs 0.835 oz. The piston rod is made hollow and at the upper end is tapped to receive the swivel head, which contains a ball-and-socket joint for the link connecting the rod to the pencil motion. Adjustment for height of the atmospheric line is obtained by screwing the swivel head in or out of the piston rod. The upper end of the piston spring is screwed onto the indicator cap, the latter being knurled to permit easy handling.

The pencil motion is based on the pantograph and gives an accurate vertical motion to the pencil point as long as no wear occurs at the several pins. The linkage parts are of tool steel to secure strength with lightness. The piston movement is multiplied five times, giving a pencil-to-piston travel ratio of 5 to 1.

The drum is $1\frac{3}{4}$ in. in diameter and is provided with a coil spring, the tension of which may be altered by

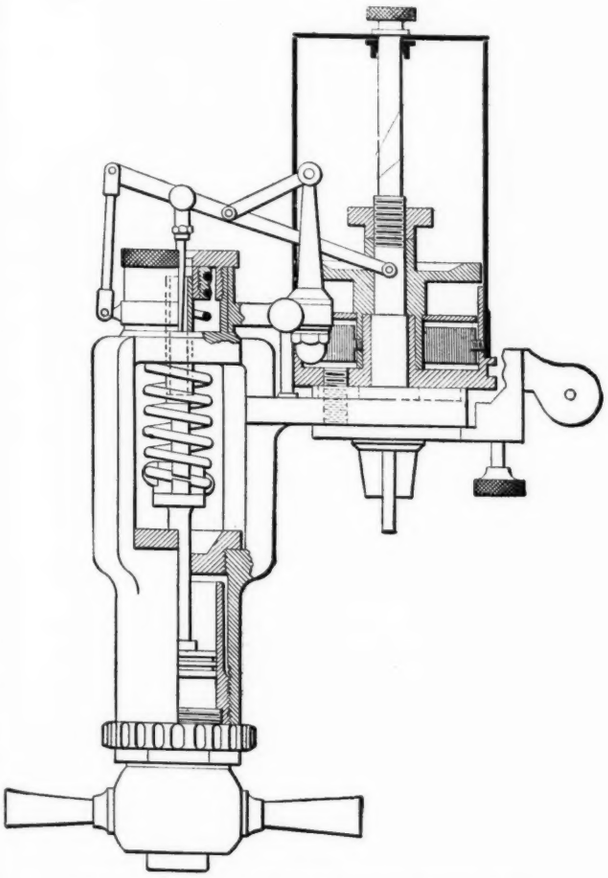


FIG. 3. AMERICAN-THOMPSON INDICATOR

removing the drum and then raising the brass spring holder off the drum post and turning the holder to the right or left as required to give the desired tension.

American-Thompson Indicator

In Fig. 3 is shown the American-Thompson Indicator with outside spring. The barrel is of brass and screws into the brass housing with the upper end of the barrel free. The piston, which is fitted with two sealing grooves, has an area of $\frac{1}{2}$ in., and in gas-engine indicators is made $\frac{1}{4}$ in. in area. The weight of the standard piston and rod is 1.56 oz.

The piston rod of steel screws into the piston body and carries a lug to which the lower end of the spring is screwed. The upper end of the single-coil spring screws onto the indicator cap. The inside of the piston rod is threaded at the upper end and receives the swivel link or crosshead. By screwing the crosshead in or out, the atmosphere line may be adjusted as desired. The pencil motion is the Thompson, based on the pantograph principle, and, including all the moving parts, weighs

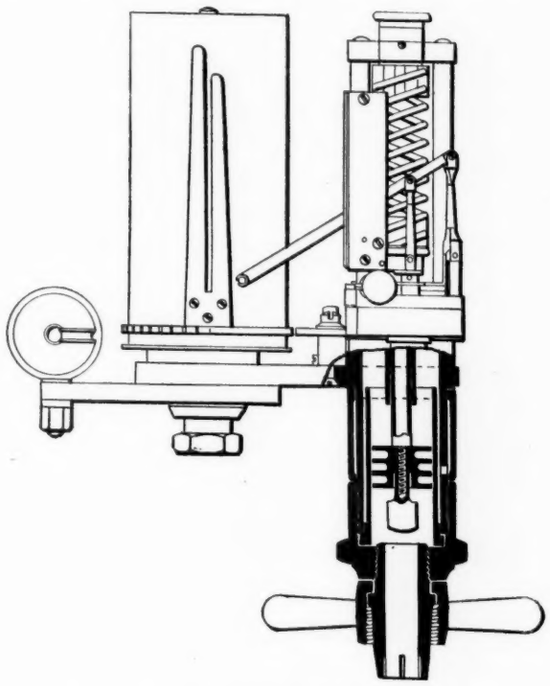


FIG. 4. TABOR OUTSIDE-SPRING INDICATOR

0.38 oz. The pencil travel bears a ratio of four to one to the piston travel.

The drum ordinarily supplied is $1\frac{1}{2}$ in. in diameter, although a 2-in. drum can be furnished. The drum spring is a spiral ribbon and may be adjusted to give any desired tension.

The Tabor Indicator

Fig. 4 illustrates the Tabor indicator with outside spring. The barrel is of bronze and is fitted with a flange at its lower end, which is locked in place by the screwing together of the two parts of the housing. The piston is of steel and is in appearance made up of four separate pistons separated by lugs. The effect of these four sections is to provide an effective seal and allow any grit on the walls to settle in one of the grooves. The standard piston has a $\frac{1}{2}$-in. cross-sectional area and together with the piston rod weighs 0.51 oz. The piston rod screws into the lower end of the spring, the upper end of which is secured into the cap or yoke. The upper end of the piston rod also carries a lug which rests in the lower end of the swivel link of the indicator's pencil motion.

The parallel motion of the Tabor indicator differs from other modern indicators. It consists of a vertical plate in which is milled a curved slot. A roller on the pencil lever works in this slot, the shape of which is such that the pencil point travels parallel to the indicator piston's travel and has a 5 to 1 ratio. The design of the slot and location of the roller on the pencil bar compensates for the tendency of the pencil to move in

an arc. The ratio of travel is maintained throughout the range of pencil travel. The pencil motion, including pencil arm, links, roll and roll screw, weighs 0.46 oz.

The Robertson-Thompson Indicator

In Fig. 5 is shown the Robertson-Thompson indicator with inside spring. Here the cylinder barrel is enlarged at the lower end to take the coupling and is screwed into the indicator body, being free at the upper end to expand and contract with changes in temperature.

The piston, which is ½ in. in area, is made in one piece with the rod, and two grooves are provided on the piston surface for sealing purposes. The combined weight of piston and rod is 1 oz. The single helix spring is provided with a lower head which screws into the piston hub. The upper head of the spring makes a screw joint with the indicator cap, while the swivel head screws to the piston rod. The 5 to 1 ratio pencil motion being a pantograph, gives an accurate motion to the pencil point as long as the hard steel pivots at the several joints do not wear excessively. The drum spring is in the form of a flat coil. Adjustment of the pencil is secured by screwing the swivel head in or out of the piston rod. Adjustment of tension is secured by tightening the coil and clamping by means of the thumbnut. Drums of either 1⅝ or 2 in. diameter are supplied.

The Crosby Indicator

Although the Crosby indicator is made with an inside spring, as in Fig. 1, the present standard design embodies the outside spring. In Fig. 6 it will be seen that the indicator barrel is held in the housing or body by a flange at its upper end. The piston, which

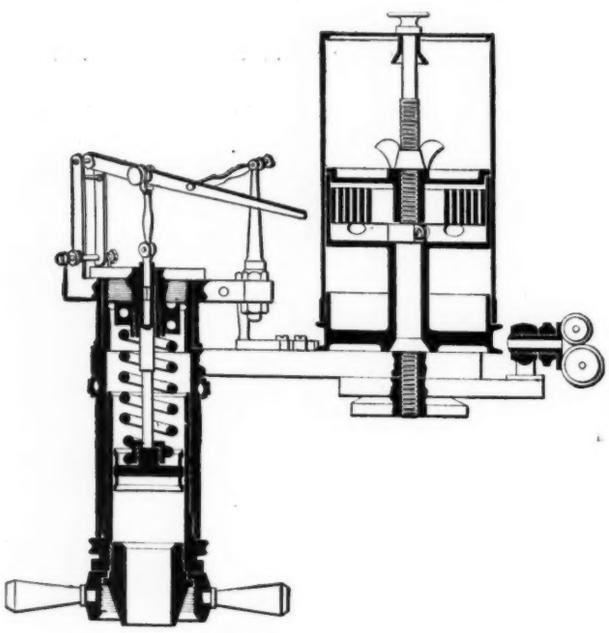


FIG. 5. ROBERTSON-THOMPSON INDICATOR

is ½ in. in area, has a spherical outer surface which makes the least possible contact with the walls. The weight is 0.4 oz. The piston rod is hollow to allow the entrance of the swivel head, which has a ball end seating in a socket bearing in the piston hub. The piston spring is a double helical, and its lower end screws onto the yoke while the upper end, which carries a head, fits into a ball-and-socket joint at the upper end of the piston rod.

The pencil motion is a pantograph and is very light, weighing only 0.25 oz. The ratio of pencil travel to piston travel is 6 to 1. The bearing pins are all hardened to eliminate wear. The drum usually furnished is 2 in. in diameter, although for high-speed work a 1½-in. drum

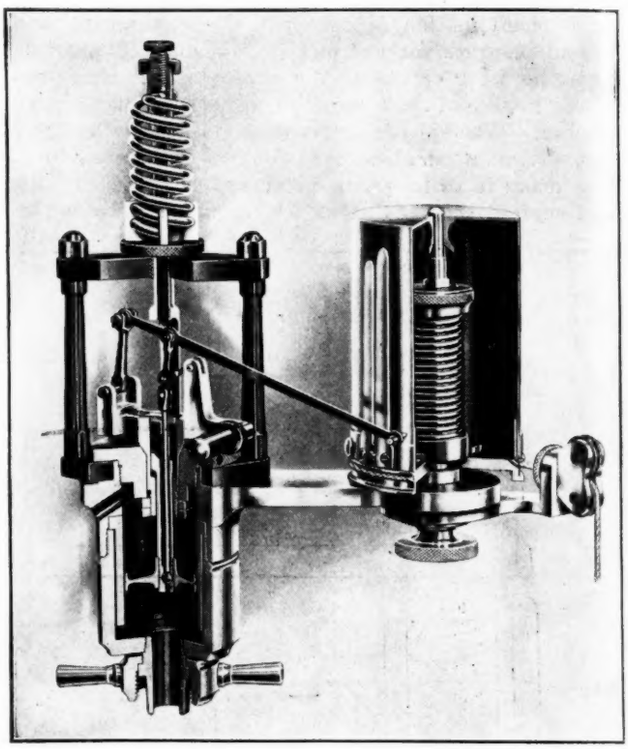


FIG. 6. CROSBY OUTSIDE-SPRING INDICATOR

may be secured. The drum spring, which is a long helical, may be adjusted for tension.

In addition to the standard steam indicator shown, a special instrument having a 1-sq.in. piston is also made. Indicators with ¼-in. piston area are also supplied for gas-engine work.

As many people ride on elevators as on all the city traction lines, according to the United States Bureau of Standards, which has been making a study of elevator safety devices. It is said also that an elevator in the Woolworth building travels about forty miles a day and makes 4,000 stops in that time. This shows well the importance of safety devices on such machinery, and the Bureau estimates that nearly three-quarters of the fatal elevator accidents that occur could be prevented by the use of well-designed interlocking devices, to prevent the shaft door from being opened except when the car is at rest in front of the door.

Both steam-turbine and waterwheel driven generators must be designed to stand overspeed. With steam turbines and engines emergency governors can be easily provided so that the generator need only be designed for an overspeed of about 30 per cent. In hydro-electric installations the inertia of the water in long penstocks is different to take care of and it is generally necessary to design the generators for an overspeed of approximately 100 per cent.

Industrial Power in Pennsylvania

Represents Annual Consumption of Over One Billion, Six Hundred Million Kilowatt-Hours of Electrical Energy of Which Approximately One-Half Is Privately Generated and the Other Half Purchased from Central Stations

PENNSYLVANIA, the second largest industrial state in the Union, has shown a marked growth in the use of electrical power since 1914. In that year the industrial load of the central stations, exclusive of lighting load, was only 608,000 hp. In the five succeeding years this had increased 214 per cent, or to 1,908,000 hp. The output of the central stations shows an increase from 880,000,000 kw.-hr. to 2,560,000,000 in 1919. Statistics are not available as to the increase in private stations during that period.

The Industrial Survey[1] that is being carried on jointly by *Power* and *Electrical World* was responsible for the sending out of 6,000 questionnaires to the larger manufacturing plants and mines of Pennsylvania, covering sixteen general industrial groups. Complete returns were received from 1,879, of which 1,033 reported using electrical energy as the main source of power. These returns have been compiled into data shown in the accompanying tables, and estimates for the whole state have been arrived at on the basis of these survey data supplemented by data from the Federal and State census.

Establishments having private generating plants reported a total capacity of 354,987 kw., of which

TABLE I—INDUSTRIAL POWER IN PENNSYLVANIA.

Data compiled from an industrial survey being conducted by the editorial departments of *Power* and *Electrical World*, covering plants of more than fifty operatives. The estimated figures are based on data of the Survey supplemented by the Federal and State census.

	Companies Reporting Use of Electricity	Capacity in D. C. Generators Reported	Capacity in A. C. Generators Reported	Energy consumed Thousand Kilowatt-hours: Reported: Privately Generated	Reported: Purchased	Estimated: Privately Generated	Estimated: Purchased	Estimated: Total	Motors Installed: Reported Rating, Hp.	Motors Installed: Estimated Rating Hp.	Distribution of Drives, Number: Reported: Belts	Reported: Chain	Reported: Direct	Estimated: Belts	Estimated: Chain	Estimated: Direct
Chemicals and products	71	2,351	12,174	24,223	37,362	62,700	44,550	107,250	43,733	76,100	873	110	1,190	1,518	192	2,070
El. eqpt. and mach.	33	1,200	21,700	35,903	10,609	110,000	12,550	122,550	35,479	93,570	1,880	33	5,097	4,960	90	13,450
Food and products	44	4,239	4,515	28,382	4,360	82,300	114,800	197,100	18,039	108,600	925	278	303	5,570	1,670	1,820
Iron and steel	531	84,655	67,777	423,052	376,859	1,290,000	1,225,000	2,515,000	431,693	1,061,000	15,026	1,146	22,507	35,600	2,720	53,380
Leather and products	56	2,665	3,485	10,564	1,957	17,000	8,020	25,020	9,206	18,900	668	99	74	1,375	204	151
Lumber and products	71	963	4,410	5,914	3,372	9,860	18,050	27,910	15,320	46,100	1,250	94	426	3,760	280	1,280
Metals and products	86	6,239	14,005	52,551	16,246	92,600	64,300	156,900	46,824	106,600	1,235	210	637	2,815	478	1,457
Coal mining	204	34,383	31,333	159,682	114,167	193,000	253,500	446,500	179,116	427,746	3,163	455	8,552	7,480	1,070	20,200
Paper and printing	78	4,472	10,515	32,052	22,808	53,000	46,200	99,200	29,212	52,800	1,852	127	333	3,350	230	600
Railroad shops	13	922	2,650	6,138	3,707	77,000	36,350	113,350	12,078	144,600	92	18	404	1,103	216	4,811
Shipbuilding	5	600	4,000	5,475	26,815	5,475	34,805	40,280	31,509	43,100	176	9	1,051	241	12	1,437
Stone, clay, glass	107	2,235	5,775	19,678	128,943	171,500	242,000	413,500	56,298	156,600	1,309	361	502	3,640	1,004	1,396
Textiles	484	10,119	7,577	32,263	39,395	47,300	90,000	137,300	55,313	106,100	4,737	953	6,879	9,090	1,810	13,200
Tobacco	15	150	150	73	227	483	3,685	4,168	181	2,152	52	2	2	622	24	24
Vehicles	16	1,789	3,750	14,276	1,006	18,100	28,200	46,300	22,250	40,600	814	26	806	1,482	138	1,470
Miscellaneous	65	2,727	1,462	8,220	8,193	88,300	126,300	214,600	13,248	168,600	723	99	501	9,200	1,260	6,400
Totals	1,879	159,709	195,278	858,446	806,026	2,318,618	2,348,310	4,666,928	999,499	2,653,168	34,775	4,070	49,264	91,806	11,398	123,176

TABLE II—PRIME MOVERS IN PRIVATE GENERATING STATIONS OF INDUSTRIAL PLANTS OF PENNSYLVANIA

Industry	Number of Companies Reporting on Prime Movers in Private Generating Stations	Power Equipment in Private Electric Generating Stations of Companies Reporting in Survey: Water-wheels No.	Water-wheels Rating, Hp.	Int. Combustion Engines No.	Int. Combustion Engines Rating, Hp.	Steam Engines No.	Steam Engines Rating, Hp.	Steam Turbines No.	Steam Turbines Rating, Hp.	Boilers No.	Boilers Rating, Hp.	Estimate of Total Power Equipment in Private Electric Generating Stations of Industrial Plants in Pennsylvania: Steam Engines No.	Steam Engines Rating, Hp.	Steam Turbines No.	Steam Turbines Rating, Hp.	Boilers No.	Boilers Hp.
Chemicals and allied products	28	8	505	24	4,747	86	9,408	6	9,040	100	30,771	222	24,300	15	23,100	259	79,500
Electrical equipment and machinery	8	0	0	2	112	14	1,905	9	29,015	49	14,783	43	5,840	28	89,000	150	45,300
Food and kindred products	17	0	0	12	2,190	45	11,552	2	600	65	15,175	131	33,500	6	1,740	189	44,100
Iron and steel and their products	228	4	348	144	48,766	477	102,471	61	72,299	701	166,406	1,450	312,050	186	220,500	2,140	507,000
Leather and its products	20	0	0	5	1,005	48	7,906	2	500	56	8,660	77	12,800	3	806	90	13,960
Lumber and its products	25	0	0	8	285	42	9,623	4	1,925	54	12,415	71	16,200	7	3,240	91	20,480
Metals and metal products other than iron and steel	27	0	0	6	940	42	10,763	12	19,065	71	18,076	74	18,950	21	30,360	125	31,800
Bituminous and anthracite coal mining	117	4	3,016	17	935	208	54,305	32	34,126	616	126,417	252	64,800	39	41,500	748	153,500
Paper and printing	27	15	3,354	0	0	113	22,837	15	8,565	112	36,475	187	37,800	25	14,200	186	60,500
Railroad repair shops	4	0	0	0	0	13	8,330	2	264	27	7,080	163	104,500	25	3,310	339	88,800
Shipbuilding	1	0	0	0	0	3	800	3	5,333	12	4,750	3	800	3	5,333	12	4,750
Stone, clay and glass	29	4	6,106	27	3,460	64	14,205	0	0	72	17,150	558	124,000	63	73,000	628	149,500
Textiles	116	7	1,078	8	725	173	32,289	10	2,375	294	53,605	254	47,300	15	3,480	432	78,600
Tobacco	3	0	0	0	0	3	220	0	0	5	700	19	1,450	0	0	33	4,600
Vehicles for land transportation	7	0	0	3	450	9	1,624	6	3,875	37	10,580	11	2,060	8	4,910	47	13,400
Miscellaneous	22	0	0	4	163	42	6,497	2	639	54	11,325	452	70,000	21	6,880	581	122,000
Totals for all industries of Pennsylvania	679	42	14,407	260	63,778	1,382	294,735	166	187,621	2,325	534,368	3,967	876,350	465	521,359	6,050	1,417,790

[1] A similar analysis of industrial power in California appeared in *Power*, Sept. 21, 1920, for the Southern States, June 28, 1921, and New York State, Aug. 2, 1921.

direct-current generators accounted for 159,709 kw. and alternating-current generators 195,278 kw. The output in 1920 of these private generating plants was 858,446,459 kw.-hr. as compared with electrical energy purchased by industrial plants and mines of 806,026,106 kw.-hr. A close study of the survey data indicates that taking the industrial plants of the state as a whole about 37 per cent of those generating all or a portion of their electrical energy reported and about 34 per cent of those purchasing all or a portion of their energy likewise reported. On this basis the indications are that about half of the electrical energy used by the industrial plants and mines of Pennsylvania is privately generated.

Reference to Table II will show that while steam engines still predominate, steam turbines are nevertheless a large factor in the private industrial plants.

Iron and steel mills rank first among the industries of Pennsylvania and are by far the largest users of electrical energy. More than half of this energy is privately generated. It is reported that about 91,700 motors are installed in the iron and steel mills of this state with a total rating of approximately 1,061,000 hp. About 29 per cent of these motors are under 5 hp.

Coal mining is the second largest user of electrical energy in Pennsylvania, consuming almost half a billion kilowatt-hours in 1920, of which 193,000,000 was generated in private plants.

It is estimated that there are over 226,000 electric motors installed in the factories and mines in Pennsylvania with a rating of over 2,653,000 hp. Nearly 40 per cent of these motors are under 5 hp.; 41 per cent are belt driven, 54 per cent are direct drive and 5 per cent chain drive.

The returns indicate that seventeen voltages are in use for the operation of direct-current motors and twenty-one for alternating current. About 30 per cent of the direct-current motors operate at 220 volts, although most of the direct-current motors in textile mills operate at 110 volts. Three-quarters of the alternating-current motors operate at 220 volts and the greater part of the remaining quarter at 440 volts.

Incidentally, returns from 612 companies indicate that three-quarters use refillable fuses. The iron and steel industry alone reports the use of over 13,000 fuses per month, and 87 per cent were of the refillable type. An analysis of the reports indicates that over 27,000 standard and 118,000 refillable fuses are used each month for the industries of Pennsylvania.

Belting Argument Decided by Cornell Tests

Late in the summer of 1921 tests of the capacity of the grain and flesh sides of leather belts were started by the Leather Belting Exchange in its research laboratory at Cornell University. These tests were carried on under the direction of R. F. Jones, director of the laboratory, and covered a period of two months of continuous work.

For the experiments five 4-in. single belts 30 ft. long were used. They came from various manufacturers and weighed from 16 to 18 oz. per sq.ft. Every effort was made throughout the test to standardize conditions and reduce the probable error to a minimum. All five belts were run long enough before the experiment to be thoroughly "run in," and had reached a condition of constant capacity when the records were taken.

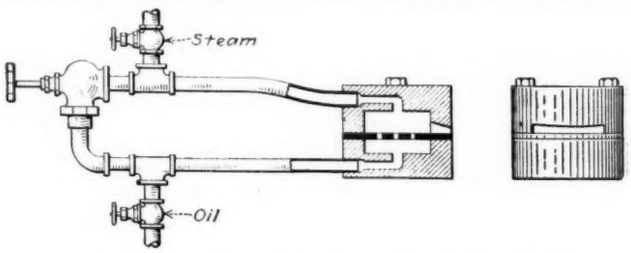
The method of procedure was to take horsepower readings from the belts, first when running on the grain side and then when running on the flesh side, the power being gradually increased until about 4 per cent slip had been reached.

In considering the results it must be remembered that a leather belt is at its lowest point of capacity when new, due partly to the elasticity of the leather and partly to the character of the surface. The newness of the surface makes it necessary to "run in" the belt when testing it. That is to say, the belt must be run for a sufficient time to permit it to reach its maximum capacity for power transmission. As an example, one belt under test at the Cornell Laboratory transmitted 12 hp. at a slip of 1.2 per cent when first put on the pulley. After five hours' running it reached 19 hp. with the same percentage of slip and the same tension. At the end of thirteen hours it transmitted 24 hp., and it reached 31 hp. after twenty hours with a slip of 1.6 per cent. According to horsepower tables its scheduled transmission should have been 26 horsepower.

There is not space here to review the results of the individual tests, but it may be said that they clearly indicate the superiority of the grain side. Under reasonable shop tension the flesh side will average only 50 to 60 per cent as much horsepower as the grain side. At higher tensions, however, the flesh side will average from 50 to 100 per cent as much power as the grain side, depending on the belt, the tension and the conditions of service.

Ideal Fuel-Oil Burner

Ever-increasing demands for fuel economy have brought out many devices for the efficient burning of fuel oil. One of the latest is the Ideal oil burner, which, as shown by the illustration, is simple in the extreme,



PIPING AND SECTION THROUGH BURNER HEAD

there being but three parts: The top casing, containing the steam chamber; the bottom casing, containing the oil chamber; and the vaporizing plate, separating these two chambers and making the steam chamber serve as well as a mixing chamber. It is designed to burn without excessive carbonization.

This burner is manufactured by the Ideal Oil Burner Co., Inc., Port Arthur, Tex. It is designed to produce complete atomization of the fuel oil so that intimate mixture of the particles of oil thus formed occurs with the air necessary for combustion. Its construction is simple; it does not leak or clog readily; it is subject to quick adjustment and control, dependent on load; it is not restricted as to grade of oil used; it has no parts to wear out easily; it atomizes without excessive noise or smoke; it gives a steady flame with no fluctuation, whatever the oil, and it can be removed from the line, easily and rapidly cleaned and reinstalled.

EDITORIALS

The Steam-Engine Indicator

IN THE last issue of *Power* was commenced a series of indicator articles which is designed to be more comprehensive than any treatment of this subject yet published. In addition to the usual instructions for the selection, care, attachment and use of the instrument, the interpretation of the diagram will be exhaustively considered, practical directions for setting the valves of different types of engines, pumps and compressors will be given, and the use of the indicator upon the refrigerating machine and the internal-combustion engine explained.

There is much to be found out from the indicator diagram besides the horsepower that an engine is developing and the way that its valves are set. From its analysis much may be learned of the extent to which the efficiency of the engine is affected by the exchange of heat between the working medium and the containing surfaces. A diagram showing, not the pressure on the piston at each instant of the stroke, as does the diagram from the indicator, but the force moving the crankpin at each instant of the revolution can be plotted from the indicator's diagram, and throws a lot of light upon regulation and noisy operation, especially at high rotative speeds. By a simple process, which anyone who can use an indicator intelligently can follow and which the articles will make clear, the pressure-volume diagram of the indicator can be transferred to the temperature-entropy plane, showing the use that the engine makes of the heat that is supplied to it, the path that the heat follows in its passage through the cylinder, what proportion of it is converted into mechanical energy and what becomes of the rest. These articles will bring all these processes within the grasp of the reader of only ordinary mathematical training. We shall be glad to have suggestions, as they proceed, as to phases of the subject that might be more fully developed or inquiry as to points that are not entirely clear.

One Item in the Coal Bill

IN ITS résumé of strikes and loss of working time due to strikes in coal mines in the United States the United States Geological Survey weekly coal report again brings to mind an important item in the cost of coal, which the user pays without much appreciation of its magnitude. The data presented do not make clear just what the actual money cost of strikes in coal mines may be, but one can well imagine that the bill is large when a total of 15,600,000 man-days is lost in a single year.

Wage agreements for coal mining must give consideration to the total annual income of the miner rather than only to the daily, hourly, or ton wage unit. The miner and his family must live and spend through the entire twelve months. An income must be provided adequate to maintenance upon a decent American scale of living for the entire period. However, it must be clearly recognized that any interruption in work makes it necessary to have the wage unit higher for every hour of employment or for every ton of coal actually mined, since all wages are paid upon time of actual employment or for the coal actually mined and handled. It is a serious matter, therefore, when almost a half million of our coal miners are out of work on account of strikes for an average period of six weeks apiece; yet this situation prevailed in 1919.

Of course other things than strikes cause decreased production and lack of employment for the miners. No time in recent years has this fact been more strikingly shown than during the calendar year just closed. As a matter of fact the average coal production since the first of last August has been approximately ten per cent less than during the corresponding months of 1919 when the great strike so seriously interrupted coal mining. During this period there have been weeks when the interruption of mine operation on account of "no market" for coal resulted in over fifty per cent loss of operating time, a condition which is serious indeed for operator and miner alike.

The evil of discontinuous employment in coal production is obvious. The remedy is not easy to apply; but it is well for the user to remember that he pays as one item in his coal bill for any such interruption. It will perhaps then be easier for him to appreciate that he must do his best to stabilize the rate of production and the regular employment of miners by purchase of coal on a systematic basis instead of at times of peak demand.

Adjustable-Speed and Varying Speed Motors

ONE of the besetting evils of the human race is the habit of calling things by other than their proper names. In this respect engineers are frequently as guilty as anyone else. There may be some excuse for this where no definite standard name or definition has been adopted for a device, method or term. However, it is not uncommon to find standard terms used by those who know better, for something entirely different from what the recognized standard definition gives.

Two terms that are perhaps subjected to as much misapplication as any others are adjustable speed and varying speed. As applied to motors, the American Institute of Electrical Engineers has given these terms standard definitions, which were adopted a number of years ago.

Adjustable-speed motors are those, "in which the speed can be varied gradually over a considerable range, but when once adjusted remains practically unaffected by the load, such as a shunt motor designed for a considerable range of speed variation." On the other hand, varying-speed motors are those, "in which the speed varies with the load, ordinarily decreasing when the load increases, such as series motors, compound motors or series-shunt motors." In the former the speed is practically constant after being adjusted, irrespective of the load, whereas in the latter the speed may vary

through wide ranges, as in the case of the series motor, with variations in the load. According to these definitions a motor whose speed can be gradually adjusted to some given value and operated at this value, is an adjustable-speed motor. In this class the only machine in use on a commercial scale is the direct-current shunt motor with some means provided for adjusting the number of magnetic lines entering and leaving the armature from the polepieces. All other types of commercial machines fall in different classes, such as constant-speed, varying-speed, multi-speed machines, etc. Therefore, there appears little excuse for calling a shunt motor with field control a varying-speed or a variable-speed motor. Laxity in the use of these terms by those who are in a position to know better, only leads to confusion and defeats the purpose of standardization.

A Midwinter Inspection for the Plant

DURING the recent summer months many plant engineers found difficulty in getting the management to approve even the relatively small expenditures needed to keep the steam-generating and steam-using equipment in good condition. This was due in part to the business depression and in part to a peculiar trait of human nature that makes it hard for a man to appreciate the seriousness of heat losses when he himself is suffering from an excess of heat.

The advent of cold weather and the recognized upward trend in the nation's business should do much to change this state of mind. It would therefore seem that, in such cases, this would be a favorable time to make a careful survey of the plant in order to submit to the management a statement of the condition of the equipment, together with an estimate of the expenditure required to put it in first-class condition.

In such a survey it is worth while to check up on all those little heat leaks that are of such importance in the aggregate. Most plants have a few feet of bare steam piping or at least sections that feel hot to the hand, showing that the insulation is not doing its full job. Likewise, there are few plants where a careful inspection would not lead to the discovery of leaky traps, valves and joints. Finally, many boiler settings leak enough air to make a serious dent in the coal pile. Each of these losses is large in comparison with what it would cost to fix it. So, with the help of changing conditions and a statement of the exact facts, it should now be easier for the engineer to secure the co-operation of those who "hold the purse strings" to the end that the "purse" may be fuller in the years to come.

Apprentice System in the Power Plant

IT IS one of the mysteries of industrial life why a man should be expected to devote years in training in order to keep account of the money spent, while the spending is indifferently placed in the care of a person who may or may not be versed in the art of securing full value for each dollar.

Of the total cost of manufacturing that of power ranges from four to eighty per cent. In the offices are to be found accountants or auditors who, after years of subordinate duties, pass their time in checking up the last penny that has been spent, while down in the power plant dollars in the shape of coal and steam may be wasted by an engineer who may have only sufficient experience to pass the examining board—and in many states even this is not necessary.

The isolated plant, if it is to continue to exist or if it is to show efficiencies above those of the present day, must be placed in charge of men who are well trained in their calling. It is hopeless to expect better results in a plant where the engineer in charge and those under him do not possess the experience and training so necessary if dollars are to be saved.

The logical step is the application of the apprentice system to power-plant work. Of late years, it is true, this system has been more or less abandoned in the machine shop for the reason that it is not required in the training of machine operators, such as drill-press, lathe or milling-machine men. The power-plant engineer in the range of his activities is comparable to the old-time machinist or toolmaker. The required experience cannot be secured by a few months spent as an oiler, but does require several years spent under the instruction of a real engineer.

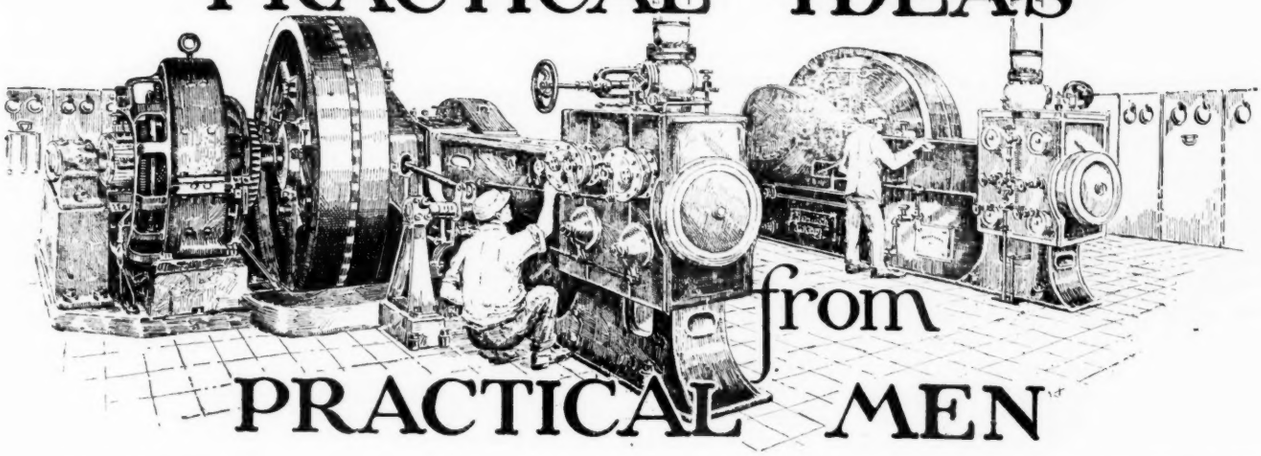
There is no reason why boys of, say, sixteen or eighteen years of age should not be taken into the power plant and given four years of training. The training could start with the wiping of machinery, progressing month by month to cover all the details of operation, adjustment and repairs of all the machinery in the plant. At the end of his training the boy, now grown into a man, would be able to face any examining board and could be placed in charge of a plant to the entire satisfaction of the owner.

The objection that might be raised to the plan is that already the engineers have associations and societies devoted to the education of the engineer. These agencies are praiseworthy as a means of encouraging the engineer to progress with the development of the science of engineering, but unfortunately do not reach the man who is not already an engineer. Some form of the apprentice system is highly desirable.

No matter how carefully a plant is operated and maintained or what provisions are provided against a complete shut-down due to some failure of the equipment, this danger is ever present. Therefore it is necessary to provide for such an emergency in advance, or the operating force may be at a serious disadvantage in restoring service. A few efficient lighting units supplied from a low-voltage storage battery, if no other reliable source of power is available, may be one of the most important factors in restoring service if the plant should go dead. Trained men knowing what to do are seriously handicapped unless sufficient light is available to do quickly those things necessary for the restoration of service.

The average coal production is about two and seven-tenths tons per day per miner. When all the other help concerned in the mining, preparation, transportation, distribution and firing of coal is included, it is probable that on the average the use of one ton of coal involves the working of one man all one day. A saving of twenty-five per cent on our consumption of some two million tons per working day would save the labor of half a million men. To put it another way, if we are wasting twenty-five per cent of our coal half a million men are toiling to no purpose, to say nothing of the needless inroad upon our most valuable natural resource.

PRACTICAL IDEAS from PRACTICAL MEN



Power-Plant Instruments from the Fireman's Point of View

Much has been written about what instruments are necessary or desirable in boiler-room operation by engineer and manufacturer, but little has been said as to what the fireman actually thinks of them or of the benefit he gets from them in regular operation.

The average fireman employed in the modern plants is careful, diligent and anxious to do his best, but the physical requirements of the job are nearly up to his limit of endurance, and he has little energy left to puzzle over meter readings that do not appear to him to have any consistent relation to the operation of the boilers, or to go to extra trouble to follow out directions that seem to be a whim of those in authority to make him work more without any visible improvement in results.

Even where the chief engineer is deeply interested in economical operation and free to devote considerable time to the boiler room and to the instructing of the firemen, much of the actual detail must be left to them, and in the final event it is up to them to keep up the steam. As this is what this job depends on, he usually takes a serious interest in everything connected with it and the relation to work out on the basis of the instruction as to the purpose and in the readings of the meters and his observations of how these correspond to boiler conditions.

At best, meters can only be a guide to conditions and will never dispense with judgment on the part of the fireman, who may at times be compelled to tolerate poor conditions to avoid having the worse; as for instance, sacrificing efficiency for capacity.

In a medium-sized plant equipped with various recording instruments, etc., and operating at between 125 and 175 per cent of boiler rating, it has been interesting to watch the use made of the various instruments. The plant is equipped with underfeed stokers and the draft is limited by the size of the stack and flues so that about 200 per cent of rating is the maximum capacity that can be developed, and when this is approached, as on occasional peaks, everything must go perfectly.

The recording steam-pressure gage probably gets the most attention, and when steam starts down suddenly after the forced-draft fan has been speeded up to the limit, and it is evident from the flow meters that the trouble is due to an increase in demand for process steam, if it seems advisable, the fires are leveled and the chart is consulted every minute or two to see if the line is beginning to bend and finally to flatten out and turn up again. When it does finally start up, the slope of the line is watched to see how quickly the steam is coming back, so that if necessary it can be checked in time to avoid blowing the safety valves.

Since the feed pump and heater are located in another room, the water tender watches the feed-water temperature recorder and pressure gage closely, as it is insisted that the feed temperature be carried to a maximum and as evenly as possible, which is done cheerfully as the boilers steam that much easier and the pressure gage gives a satisfactory measure of the working of the feed pump and feed valves.

Next to the steam-recording gages the flow meters are most closely watched, as they indicate the distribution of load between the boilers and enable the fireman to see at once if any boiler is falling behind and to investigate and remedy the trouble at once. The attention paid to these instruments is evident from the promptness with which any apparent trouble is reported and the insistence on having it repaired as soon as possible.

The remaining instruments receive only casual observation, the draft gages chiefly in checking up when a boiler apparently fails to steam, and the other instruments but little. These other instruments are of considerable value to the chief engineer in enabling him to keep check on the operation of the plant. The flue-gas-temperature recorders give warning of anything seriously wrong with the boiler cleaning or baffles, although this is supplemented by weekly physical inspections, and the CO_2 recorders show the combustion conditions as maintained.

One way to disgust firemen with meter installations is to use them as a basis for poorly arranged bonus systems. In fact, it is doubtful if any individual bonus system can be arranged in a power plant that will not cost more to supervise to prevent cheating than it returns in savings. Most of the methods of "beating the bonus," from stealing coal from the following shift to fooling the CO_2 recorder, have been well worked out as occasion seemed to require. One of the worst features of the individual bonus is the hard feelings created between the honest, conscientious, hard-working man and the other more clever, unscrupulous and better-paid man who is beating the game.

H. D. FISHER.

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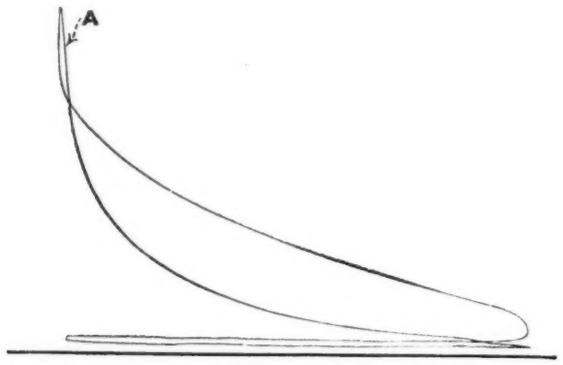
Peculiar Diesel Indicator Diagram

I had occasion not long ago to make some repairs on a Diesel engine. Among other things I put in new crankpin bearings. Not knowing the exact clearance between the cylinder head and piston necessary to secure proper compression pressure, I did not use any shims between the big end and rod. I figured that I



A PECULIAR INDICATOR DIAGRAM

would use my indicator and then insert shims until I secured a diagram showing the proper compression, which is about 450 lb. per square inch.

After making all repairs, I set the fuel valve of each cylinder to open 4 deg. ahead of dead center. No reducing motion was found, and so I rigged one up to work from the end of the engine shaft, although this made rather a long indicator cord.

To my surprise, upon taking a card I found that the diagram appeared as illustrated. I discovered that my compression was low and so inserted more shims until I got as high as 480 in. per sq.in. However, all the cards taken resemble the sketch, which I send, since it shows the expansion line and the compression line very distinctly. I was able to pull the engine's rating with 70 atmospheres of injection air pressure.

I would like to ask any readers of *Power* who understand Diesel engines what causes the loop where the expansion line crosses the compression line. From the diagram it seems that the expansion pressure dropped below the compression line as the piston moved downward. Will someone explain this diagram?

Philadelphia, Pa. P. K. JONES.

Connected Counter to Valve Shaft

In a gas-compression station of 3,000 hp. comprising seventeen engine units, I was confronted with the problem of keeping in operation revolution counters which were an annoyance and unsatisfactory. In order to keep the operation reports straight, a simple method of installation was adopted.

The revolution counters were formerly set up on pipe stanchions and connected to the main crankshaft, and the connecting lever was continually breaking and as a result was in use but little. The counters were set on a bracket near the valve operation shaft which makes but one-half the revolutions of the main crankshaft. The first counter wheel was removed and replaced and an extra pin or cog put at the fifth figure, which made it possible to arrive at the true revolutions of the engine without the use of a multiplier.

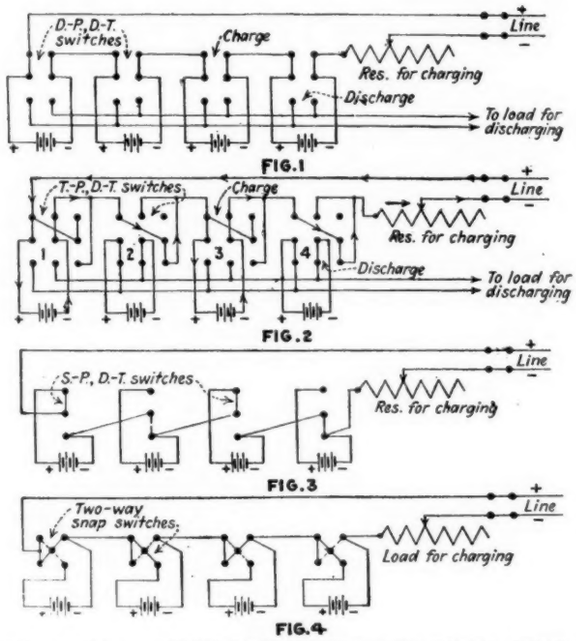
Dixmont, Pa. CHARLES A. PATTERSON.

Connections for Charging Storage Batteries

Storage batteries for one purpose or another have become a part of practically every power-plant equipment. If they are not used for control and exciter purposes, as in the large and medium-sized alternating-current stations, they are used for signal purposes, emergency lighting, etc.; and where trucks and automobiles are used about an industry, it is frequently the power-plant engineer's job to look after the batteries on the vehicle. In charging and discharging small batteries, various switching schemes have been used, some of which are shown in the figures. Each is arranged to cut four batteries in series for charging and in Figs. 1 and 2, in parallel for discharging at heavy current.

If the batteries are all to be charged simultaneously through the same resistance, the connection may be accomplished with a double-pole double-throw knife switch for each battery, using the connection in Fig. 1. If, however, it is desired to charge some of the batteries and at the same time discharge the others, it becomes necessary to install three-pole double-throw switches with the connection as shown in Fig. 2. This connection completes the series charging circuit as soon as the switch is thrown on discharge, as indicated by switches *2* and *4*.

There are several methods of connecting the batteries with single-pole single-throw switches provided the only object to be accomplished is to cut easily the cells in series for charging and not to place them in parallel for discharge. One scheme is shown in Fig. 3. If two-way



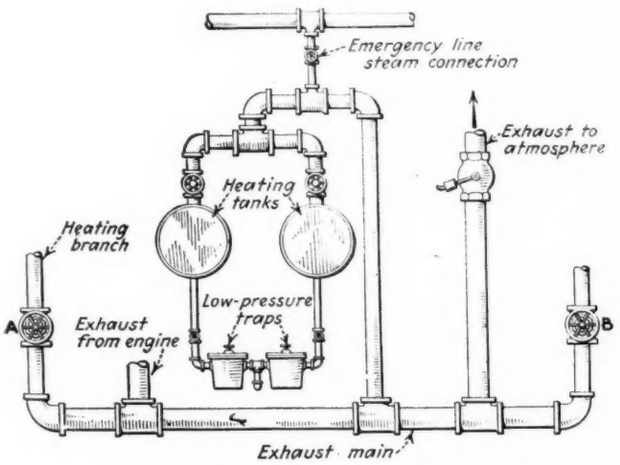
FIGS. 1 TO 4. CONNECTIONS FOR CHARGING STORAGE BATTERIES

snap switches are used, they may be connected as in Fig. 4. This connection is often used where it is desired to cut a battery into or out of the charging circuit without interrupting the circuit. There are on the market plugs and receptacles designed especially to cut batteries in and out of the circuit, and also to connect them in various combinations of series and parallel in order to get various current values at different voltages.

Orange, N. J. VICTOR H. TODD.

Improving Steam Distribution

The heating tanks for furnishing hot water in a four-story building are supplied with steam from the main pipe, into which a 250-hp. engine and various auxiliaries exhaust, the connections being made as shown in the sketch. The building also is heated with steam from



REPLACED VALVES A AND B WITH AUTOMATIC BACK-PRESSURE VALVES

the same exhaust main, a vacuum system being used. The work going on in the building is of a nature that demands an abundant and continuous supply of hot water. The heating of the rooms is of lesser importance.

When the heating plant was put in service for the winter, the engineer had difficulty in heating the water to the requisite temperature. He attempted to correct this by disconnecting the heating coils in the tanks from the vacuum return line and reconnecting them to a pair of low-pressure steam traps, as shown in the sketch. But this did not mend the trouble by any means.

It was then suggested that the difficulty be overcome by supplying live steam to the tank coils through a reducing valve. But the engineer was averse to doing this, because heating the water with live steam would mean a considerable increase in the quantity of coal consumed.

The piping for supplying the building with heat is divided into two main branches, with a valve for cutting out each branch, as indicated at *A* and *B* in the sketch. The engineer found that by partly closing these valves he could heat the water to the desired temperature and still send enough steam into the heating coils and radiators throughout the building to keep the place reasonably comfortable. By doing this he realized a gage pressure of about 1½ lb. per sq.in. in the tank coils, while the portions of the system beyond the valves *A* and *B* still maintained a vacuum.

But keeping a constant back pressure in the tank coils by this means called for frequent adjustment of the stop valves *A* and *B*. If these valves were set to give the necessary back pressure when the engine was exhausting lightly, the pressure would mount up when the engine began sending in a heavy exhaust, and this would throw the relief valve to the atmosphere wide open.

To avoid this trouble, the engineer decided to take out the ordinary stop valves at *A* and *B* and put automatic back-pressure valves in their places. These valves are filled with dashpots for cushioning the discs in their action.

By proper adjustment of the weights attached to the back-pressure valves, the engineer is now able at all times to keep a pressure of about 2 lb. per sq.in. on the hot-water side of the system, while the rest of the system is operated under a 10-in. vacuum.

St. Louis, Mo. A. J. DIXON.

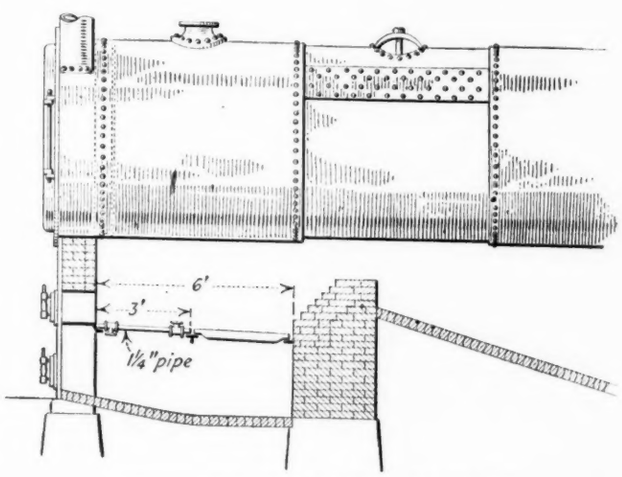
How Pipe Grates Kept the Plant Going

Some years ago I was running a small steam plant consisting of an engine and a 60-in. return-tubular boiler, the furnace of which was equipped with stationary herringbone grates, none of which was in the best of condition.

One Saturday afternoon, about an hour before shutting-down time, one of the grate's lengths failed completely. There were no new ones in the vicinity and no means of getting one in time for starting up Monday morning, and I decided that the broken grate bar could be substituted by using iron rods cut to the proper length. Upon second thought it was believed that solid bars would not answer the purpose as they would get hot and doubtless sag in the center.

Then it was decided to use ordinary 1¼-in. pipe as there would be a circulation of air through them, but the fireman suggested that the pipe ends would get filled with ashes and would be no better than solid bars. I decided that he was right, but got over that difficulty by connecting two tees in each pipe length, as shown The tees were placed three inches from the end and each was fitted with the side opening pointing up and down as shown. The entire length of each pipe section was three feet.

The idea was that the tees would provide an air circulation through the pipe. Whether there was a cir-



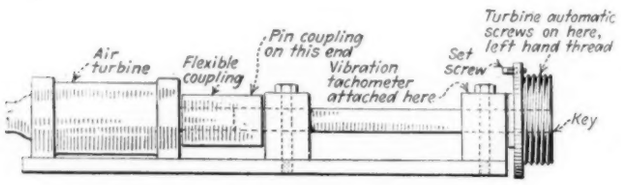
SUBSTITUTE PIPE GRATES IN PLACE

culation was never known, but the substitute grates lasted until a new set arrived. One thing in their favor was that the fire was not forced and soft coal was burned. Of course the pipes were a little lower than the rest of the grate surface, and the tee joints made an uneven surface, but they saved the day.

Rome, N. Y. P. J. HOSTER.

Rig for Testing Turbine Automatics

Do operators overspeed their turbines just to try out the automatics? Is there no other way to be sure that they will operate? Our turbines have been in use ten years, and we have never overspeeded them to test out the automatics. Our machines are among the most satisfactory in point of operation as well as in length



TESTER FOR TURBINE AUTOMATICS

of time in service that have been installed by one of the largest manufacturers.

We are operating three 6,000-kw. machines. The automatics screw onto the end of the rotor shaft with a left-hand thread. We take them off and test them out whenever we think they need it. We can test one fifty times with our rig while making one test on the turbine itself and with no risk from dangerous overspeeding.

We use a rig assembled out of one boiler-tube cleaner turbine, one piece of heavy iron to act as a base plate, two pairs of stoker-engine connecting-rod brasses, a piece of shafting, made up expressly for the purpose, and a few machine bolts and other pieces that are easily found around any large plant. The sketch will give any engineer all the pointers that he needs to enable him to construct an apparatus that will fit his own particular case, if he has a turbine on which the automatic can be removed.

Care should be taken to have the automatic locked on the thread portion by a screw or other means, so that there can be no possible chance for its coming off, or it may do serious damage. The regulation 4-in. air-driven boiler-tube turbine gives sufficient power and speed, and it is easily held at any speed desired. A variable-speed motor would, of course, be good for this purpose; we did not happen to have one handy, so we used what we had.

After testing repeatedly to make sure that the speed is what is wanted and that the automatic will repeat itself at the speed, we then stamp them with the date when tested and the speed at which they came out about as follows: 3—16—21—1680. That leaves no doubt as to when they were last tested or at what speed.

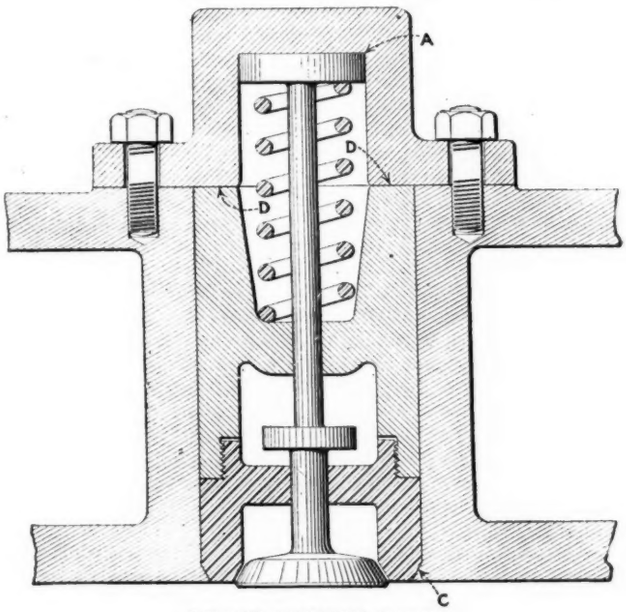
Norwood, Ohio. B. D. CARTER.

Leaky Compressor Valve Affects Coil Temperature

Some time ago I had an experience that may interest *Power* readers. We have in our plant two ammonia compressors; one is a two-cylinder vertical, and the other is a single-cylinder horizontal; both are double-acting.

We have three suction lines from different parts of the plant so arranged that any number of cylinders may be operated on either line or any number of lines may be operated by either cylinders or all may be operated together. We operate most of the time with one cylinder on each line, having them separate, as we find this gives the best results. The different parts of the system require different temperatures and different suction pressures. At the time of which I write, we were carrying one of our storage rooms at zero temperature. I noticed that the temperature was not coming down as usual and that the suction line was not frosted back to the interchanger or economizer. The expansion valve was opened a little, since it looked as if the coil was not getting enough ammonia; still it did not frost back. The ammonia receiver was next examined to see if the ammonia supply was low, but there was plenty in the gage glass when the compressors were running.

I then turned my attention to the compressor. The suction pressure was higher than usual on this line, and the suction valve bonnets were warm instead of cold on this cylinder. At the first opportunity the suction-valve bonnets were removed, as we expected to find a broken spring or a gasket squeezed out at *D* which would allow gas to leak through the ground joint between cage and cylinder at *C*, but I could find nothing the matter. The next time we shut down we examined the discharge valves, but found them all right. Noticing that the lower suction valve bonnet was the warmest, I placed my ear against the bonnet and could hear a slight hissing noise on the discharge stroke. This bonnet was removed, and on closer examination a slight bright place was found in back of bonnet at *A*, and it was evident



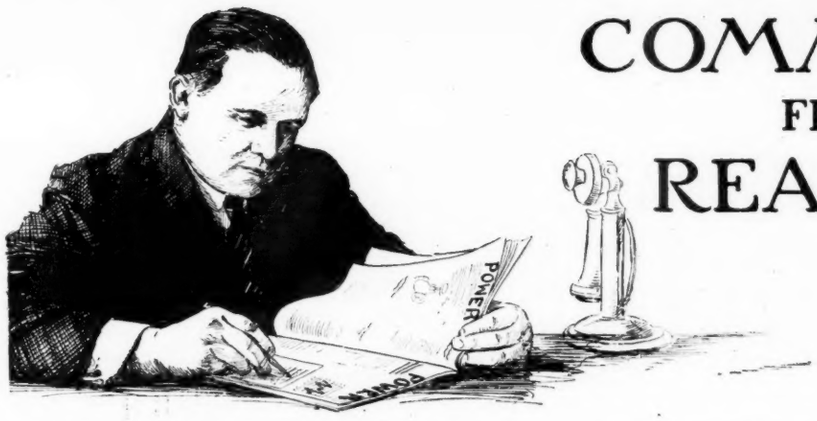
LEAKY SUCTION VALVE

that the clearance between the valve stem and bonnet was not enough and the end of the stem struck the bonnet at *A*, holding the suction valve slightly off its seat. About one-eighth of an inch was ground off the end of the stem on an emery wheel and the valve replaced. The cylinder was started up and did its work as usual.

C. E. FREEMAN.

Salem, Ohio.

At the Lakeside station in Milwaukee, where powdered fuel is burned, it was noted recently that after operating at a 160 per cent rating for five minutes the fuel feed was stopped and the boiler pressure remained between 270 and 275 lb. for three hours. During the next twelve hours the pressure dropped to 160 lb. The boiler was then brought up to rating in about five minutes.



COMMENTS FROM READERS

Why Do the Lights Flicker?

After reading some of the explanations given for the trouble referred to by W. J. Groom in the Oct. 18 issue, as to the cause of the flickering lights, I decided to submit my experience. Some time ago I was the watch engineer in a power plant having direct-current steam-engine-driven generators. Both units were from the same manufacturer, prominent in the construction of this type of machinery. They worked satisfactorily for about a year after they were installed, then trouble with pulsating currents began to manifest itself. We looked for the cause in the governor and particularly in the oil gag pot, but found no trouble. This gag pot had a fault of pumping the oil out around the stem. I might say that the flickering of the lights was more noticeable on the watch of one of the engineers than the others, notwithstanding the fact that this man was competent. Finally, one day the pulsations were so aggravating that the generator was taken out of service. When I came on watch, the chief engineer put it up to me to locate the trouble. The usual survey of the governor was made and no trouble found; then the unit was prepared for service. I started it up in the usual way, but let it run idle for a period longer than was customary, then cut the machine in and the running engine out. The lights began to flicker more than usual, and things looked distressing. I then applied to the commutator a good commutator compound and noticed that the flickering began to diminish. After all the brushes had received a dose of the compound, the flickering was entirely eliminated.

My discovery showed conclusively that our trouble was in the commutator and brushes and not in the governor. It also showed why one of the engineers had more trouble than the others—because he failed to use the compound. However, I will state that I was using the compound as a lubricant without knowing its effect on the current, since I consider liquid lubricants objectionable on account of carbonizing the mica insulation of a commutator. ALEX MORVAN.

New Orleans, La.

In answer to Mr. Groom's question I would say that in a plant in my charge, there were two high-speed engines—one running 400 r.p.m. and the other 480 r.p.m. The former gave me a lot of trouble. This engine was equipped with a single-bar inertia-type governor and a piston valve. I experimented with different kinds of grease and oils on the governor bearing, which had a brass bushing about $\frac{1}{8}$ in. thick, and at last I found that by using sperm oil the lights would hold steady.

If the governor is of the centrifugal-shaft type, the trouble may be that the force of the weight spring and the centrifugal force of the weights are unbalanced, and one keeps overcoming the other, causing variation in speed. To remedy this, give less tension on the spring to decrease the sensitiveness, and change the weights to get the desired speed. Hunting or racing may be caused by the governor parts sticking, owing to friction. An engine in a plant that I was in some time ago was running very unsteadily, and after an investigation it was found that the governor springs did not have the same tension. After the springs had been adjusted, the engine ran all right.

If Mr. Groom's engine has an inertia governor, I would suggest that it be taken apart and cleaned. If he is using grease or heavy oil, I would advise trying a lighter grade and taking care that the stuffing box is not too tight. L. N. WEBSTER.

Springfield, Mass.

Upon reading the explanation as to why W. J. Groom's lights flicker, I wish to suggest that the trouble may be due to the wires from the switchboard to the machines or over the entire system not being large enough, and when the increased current required for starting motors is transmitted, it causes a temporary drop in voltage, which is manifested by the lamps flickering. Should this not be the case the next probable cause could be that the governor on the engine is at fault and may not be sensitive enough to prevent a variation in speed and consequently in voltage when starting up the motors. If the generators are belt-driven, the trouble could be caused by slippage or a poor connection in the belt. However, belt trouble should be easily detected if this is the case. H. W. ROSE.

Victoria, Tex.

Wrecking Compound Engines

The article on "Wrecking Compound Engines," by W. H. Wakeman, in the Nov. 29, 1921, issue, should not be taken too seriously by the operating engineer, as it contains certain statements that do not accord with facts.

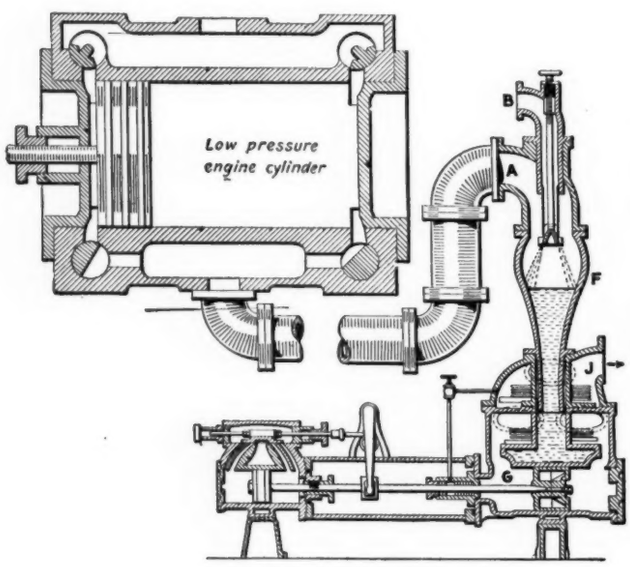
The author asserts that with four pounds pressure in the low-pressure cylinder and five pounds in the condenser, the water will be pulled over into the cylinder. He cites an instance when this happened, so he claims, and to prove the case mentions seaweed having been found in the engine after the wreck. It is not at all necessary to refuse to admit the seaweed as evidence. Mr. Wakeman has made the common mistake of taking

evidence proving one state of affairs and using it in an entirely incorrect way.

Let us take the low down jet condenser with a pump as an example of condensing operation. This type of pump should more likely flood the cylinder than any other. In Fig. 1 is shown such an outfit, and the reader will observe that the water pump is required to handle all the water issuing from the spray and intake pipe *B*. The spray, mixing with the steam, condenses the latter and so gives a vacuum in the condenser and likewise in the cylinder, due to the reduction of the steam volume to the resulting water volume. The only way the water can rise up as high as the elbow *A* is through the failure of the pump to remove the water as fast as it enters through *B*.

Now assume that in the low-pressure cylinder the pressure at the end of the stroke is four pounds absolute and the pressure in the condenser is five pounds absolute. As soon as the exhaust valve is opened, these two pressures are equalized by a flow of air from the condenser to the cylinder. The water level in the condenser is at *F*, as shown, since the pump is removing the water as fast as it enters through *B*. It cannot rise to *A* and overflow into the cylinder. Mr. Wakeman may think that with only four pounds pressure in the cylinder there is a tendency for the water to rise up the condenser throat, but a little experimenting will show him that this never happens if the pump is working correctly.

In the instance he cites where seaweed was found in the cylinder, in all probability the condenser pump



ENGINE AND JET CONDENSER

was stopped before the inlet water valve was closed. This would, of course, flood the condenser and engine and any seaweed entering at *B* would naturally be carried into the cylinder.

The surface and barometric condensers will not throw water into the cylinder any more than will the jet condenser. On the other hand, all condensers should have a non-return or relief valve operated by a float to prevent flooding of the cylinder by pump breakdown.

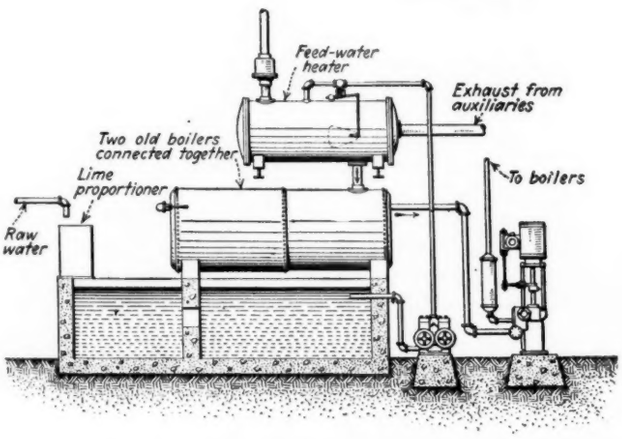
J. CASSIDAY.

Jersey City, N. J.

Lime-Soda Feed-Water Purification

I was much interested in J. Elmer Housley's article, page 810, of the Nov. 22 issue of *Power* on lime-soda feed-water purification, but I consider he makes a misstatement when he says "the bicarbonates would not be precipitated until after 212 deg. F. and consequently would not cause trouble in the pipe lines and pumps."

I am not an expert on chemistry, but I have always been taught, and my technical books all state, that the



TWO OLD BOILERS USED FOR SETTLING TANKS

bicarbonates will precipitate on the addition of the proper quantity of lime at almost any temperature (above the freezing point of course), but the process is greatly accelerated as the temperature is raised. In most feed waters calcining carbonate exists in solution with gases in the water, as bicarbonates, and on the addition of slaked lime we get two parts of calcium monocarbonate, which are precipitated, and two parts of water. Where only carbonates are present in the feed waters, it is generally recognized that lime is the most economical treatment, and soda becomes necessary only where sulphates are present.

In my opinion Mr. Housley would have got better results if he had heated his water to as near the boiling point as possible, before passing it through the softener. The scale-forming materials would then be deposited much more rapidly, and if his softener has sufficient capacity to allow the water to remain in an almost quiescent state for a reasonable period, so as to give the precipitates a chance to settle out, he should have no trouble with scale in his feed lines. In fact, one company making hot-process softeners claims that with its apparatus a filter can be dispensed with in most cases.

In the plant where I am employed, we have no regular softener, but lime is added to the cold water in a large tank, which also acts as a settling chamber for mud, after which it is passed through a heater of rather small capacity for the amount of water handled. This arrangement used to give trouble owing to the scale depositing in the pumps and feed lines, so two old boilers, with the tubes removed and baffles put in, were installed between the heater and pumps, as shown by the sketch, so as to hold the water in storage for a short time. Since this has been done, our feed lines and pumps have given practically no trouble from scale. The temperature loss between the heater and boilers is so small as to be almost negligible. Of course, if Mr. Housley wishes to handle feed water at the boiling

point, he will need to have a head of water on the suction side of his pump considerably greater than his sketch would seem to indicate. I would suggest from 15 to 20 feet. THOMAS C. PORTEOUS.

Michel, B.C.

Using Flue Gases for Cooling Turbo-Generators

An editorial in the Dec. 13, 1921, issue of *Power* explains the difficulties attending the cooling of turbine-driven generators. Washing is resorted to in order to free the air of dirt as far as possible, yet dirt does find its way into the windings, with a resultant fire hazard.

There is a cure close at hand, easily obtained and cheap—flue gas. The gas may be drawn from the breeching, or stack, cooled and washed (the washing and cooling done by the same process) and used as air is now used. The "closed" system should be employed to avoid the cost of cooling a continuous supply of comparatively high-temperature flue gases.

There are several industrial problems that can be solved by the use of the gases of combustion from boiler furnaces. I once suggested the use of flue gas in a problem involving the distillation of a combustible, but it was objected to because of the presence of oxygen in the gases. The mere presence of oxygen, however, means nothing. What is vital is, how much oxygen?

Flue gas containing as much as 16 per cent oxygen with as little as 3.5 per cent CO_2, will not support combustion, and any boiler plant that produces flue gas of this low value of CO_2 content would be regarded extremely inefficient; hence any apprehension about using the gases of combustion from the average boiler plant is groundless. C. O. SANDSTROM.

Kansas City, Mo.

Finds Catalogs Valuable

The article "This Engineer Finds Catalogs Valuable" by A. D. Palmer on page 899 of the Dec. 6, 1921, issue, recalls an incident where the reading of manufacturers' catalogs and instruction sheets proved to be a case of preparedness. A new power plant had been completed and was in operation, and plans for eliminating several smaller stations were under consideration. I was informed that when the station I was in charge of was discontinued, I would be transferred to the new plant.

I knew that the auxiliary machinery in the new plant was all turbine-driven, and as I had never had any experience with this type of turbine, I immediately requested instructive matter from the builders, which I received in due time. After studying it carefully, I filed it with catalog matter to be saved for future reference.

Eventually, I was transferred, taking the night watch at the new plant. One of my regular duties was to change the CO_2 and pyrometer charts in the chief engineer's office, and many times I found instructions relating to special work to be done. One night I found instructions to speed up one of the blower turbines that would not come up to speed. Ordinarily, with this type of turbine, all that is necessary is to set up on the governor-spring adjusting nut. After opening up the governor case, I found that someone had made an attempt to speed up the turbine without much knowledge of what he was trying to do and the spring had not been replaced properly, which allowed lost motion in one of the governor weight arms and compressed the spring until it was coil-bound; he had overlooked the steam valve.

I took the governor down, cleaned the parts and started to put it together, being careful to get the parts in according to the instructions. With this type of turbine, if the governor spring is placed incorrectly on the yoke, either one or the other weight arm will have a small amount of lost motion, but by turning the spring 180 deg. they will both be rigid. The steam valve had an opening of $\frac{3}{16}$ in. when it was taken down and the stem was slightly bent, but after straightening the stem and setting it for $\frac{3}{8}$-in. opening, all that was necessary was a few adjustments on the spring to get the correct speed.

Not only are catalogs of value for the instructions relating to machines, but many contain valuable information and tables in handy form. The manufacturers will gladly send these catalogs in most cases, as they expect they will be read and that will inform the reader of the methods of adjusting and operating their product in such a manner that it will give satisfaction.

New London, Conn. ROBERT H. LARKIN.

Dalmarnock Power Station, Glasgow

I have been much interested in the various notices you have published regarding our latest power station, and as I was closely associated with the engineers—now Electricity Commissioners for Great Britain—who were responsible for the layout of the Dalmarnock station, I trust you will allow me to reply to Mr. Landry's article in the issue of Sept. 27.

The variety of types of steam plant is certainly embarrassing to the user, but the value of the test results to the industry as a whole should be very great. In his comments on the switch gear Mr. Landry is not on sure ground, as the separation of phases is much better practice than in any of the conventional types of gear. In Great Britain, at least, it is generally conceded that the cables are the strongest part of the system, and the factor of safety in the compound-filled parts of the switch gear is decidedly higher than in the cables. There may be slight weaknesses in the switches, but this is rather pardonable in a pioneer effort, and in my opinion the makers of the gear deserve great credit for their efforts to make a real engineering job. It may also be stated that the risk to operatives has been almost entirely eliminated.

The suggestion that a jet condenser should have been used for the feed-water heating system is interesting, but as the designer of the turbine and feed-water heater is one of the best authorities in the world, we are content to accept his views for the present.

I am surprised that Mr. Landry commits himself to such a sweeping criticism of the choice of the size of the main units, as he could not possibly be aware of the operating conditions prevailing in Glasgow. Furthermore, the reports we hear of the performance of large American turbo-generators do not lead us to envy the experience of the manufacturers who installed them.

In conclusion, I hope that any American engineers who are interested will inspect the station if they are visiting Scotland.

R. B. MITCHELL, Engineer and Manager,
Glasgow Corp. Elec. Dept.

Glasgow, Scotland.

QUESTIONS AND ANSWERS

Auxiliary Steam Valve on Single-Cylinder Steam Pump

Why is it necessary to have an auxiliary steam valve on a single-cylinder pump? R. N. G.

If the main valve were mechanically connected to the piston rod of the pump, the steam port would be closed slowly toward the end of the stroke and the stroke would not be completed. Hence an auxiliary valve is necessary to operate the steam valve so that it may be promptly opened at the beginning of the stroke and remain open until the stroke is completed.

Angular Advance of Eccentric

What is meant by lap angle, lead angle and angular advance of an eccentric? R. H.

The lap angle is the angle at which an engine's eccentric must be set ahead of the crank in excess of 90 deg., in order to have the valve moved far enough to overcome the lap of the valve and obtain admission of steam at the beginning of the stroke. The lead angle is the angle at which the eccentric must be additionally advanced to obtain the desired lead or amount of valve opening at the beginning of the stroke. The sum of the lap and lead angles is called the angular advance of the eccentric.

Water Column Pressure Reduced to Ounces per Square Inch

How many ounces pressure per square inch would be equivalent to a pressure of 0.5 in. of water? J. T. B.

One inch of water pressure signifies the intensity of pressure that would be due to a column of water one inch high. A cubic foot of water at the temperature of 62 deg. F. weighs 62.355 lb., and the weight of 1 cu.in., or the pressure per square inch that would be exerted by a column of water 1 in. high, would be $62.355 \div 1{,}728 = 0.03609$ lb., or $0.03609 \times 16 = 0.57744$ oz. per sq.in. Hence 0.5 in. of water pressure would be equal to a pressure of $0.57744 \times 0.5 = 0.2887$ oz. per square inch.

Steel Boiler Settings

How are steel settings arranged for horizontal return-tubular boilers, and what is their advantage over brick settings? R. L.

Steel settings consist of an outer casing of sheet steel, riveted together and stiffened with angle irons or tee bars. The sheet steel is lined, first, with a thickness of asbestos, over which is placed a layer of clay, and then a layer of reinforced fireclay or firebrick held in place by anchors or clips placed at intervals. The principal advantage of these settings is that they are practically airtight and are not injured by the continual expansion and contraction of the boiler, nor from unequal settling of the walls. They are also advantageous for settings of boilers in locations where labor and material would not be available for laying up of ordinary masonry settings.

Patching Horizontal Return-Tubular Boilers

Should a patch on a return-tubular boiler be placed on the inside or the outside of the shell? F. N. R.

It is better to place a patch on the inside of the boiler, as the riveting and calking tend to flatten the curvature of the shell and when placed on the outside the calking is more likely to become opened by the effort of the shell to assume a circular form when under pressure. Patches below the water line always should be placed on the inside. Otherwise a pocket is formed which has a depth equal to the thickness of the shell plate and this soon becomes filled with sediment that may cause the patch to become burned.

Centrifugal Boiler-Feed Pumps

What are the advantages of centrifugal boiler-feed pumps over reciprocating pumps? W. L. D.

Centrifugal pumps have the advantages of compactness, silent running, durability and superior economy in cost of operation, attendance and repairs, and the facility with which they may be adapted to any situation where they may be supplied with power by direct connection to an electric motor or steam turbine. As boiler feeders they have the advantages over reciprocating pumps of continuous delivery without shock or pounding, regulation of their delivery by simply adjusting the boiler-feed stop valve, avoidance of packing troubles, ease of lubrication and of producing no dangerously excessive pressure in closed heaters or feed mains for any adjustment of feed stop valves or other stoppage of feed connections.

Cleaning an Exhaust-Steam Heating System of Oil

How can an exhaust-steam heating system be cleaned of oil, and how can deposits of oil out of the exhaust steam be prevented? F. A.

An exhaust-steam heating system can be cleaned of oil by filling the pipes and coils with a concentrated solution of soda ash diluted with two or three parts of water. When the system has been allowed to stand filled for about five hours, the mains and risers should be flushed with clean warm water pumped into the system or filled at the highest point, while the connections of one radiator at a time are left open. When the system is in regular operation, a good oil separator should be used for removing all oil possible from the exhaust steam at the point where it is supplied to the heating system, and the exhaust connection from the

engine should be provided with a good-sized drip left open at all times for discharging as much water and oil as possible before the exhaust steam reaches the separator.

Friction Between Plates of Riveted Joints

What allowance is made for friction between the plates of a riveted joint? R. G. S.

The friction between plates of a riveted joint cannot be depended upon as a basis for calculation. Tests of joints have shown that there is a wide variation in the holding power due to friction, and when the plates are new and clean considerable slip is discernible long before the working load is reached. The value of the frictional resistance between the plates after the rivets are brought to bearings for resisting shearing stresses is a matter of doubt, and although the friction is of more or less assistance, it is neglected by American boiler designers on account of uncertainty and relatively low value.

Rupture of Water Pipes from Freezing

At what temperature does rupture occur in water pipes when they burst from freezing? G. R. N.

Rupture occurs while the water is passing to the solid state, or just when the temperature is returning to the freezing point, which for quiet water at atmospheric pressure is 32 deg. F. and for greater pressures is about 0.0135 deg. F. higher for each additional atmosphere of pressure. During the freezing process the ice volume becomes about 8½ per cent greater than the volume of the water from which it was formed. After ice has formed, a further fall of temperature causes contraction of the volume, and when reheated to the freezing temperature the ice re-expands to the initial ice volume before it is converted to water. Rupture of iron pipes usually takes place during the process of freezing, while soft lead pipes generally expand without becoming ruptured during the process of freezing and more frequently become ruptured by expansion of the ice from local applications of heat.

How Interpole Generators Were Made To Equalize

In our plant there are five direct-current generators, three compound-wound interpole machines and two compound-wound units without interpoles. Two of the interpole machines are direct-connected to the same turbine and set in such a way that one machine is about ten feet farther away from the switchboard than the other. The equalizing busbar is on the switchboard. When these two generators are paralleled in the regular manner—that is, with the equalizer connection made between the interpole- and series-field windings—they will not equalize properly. With the equalizer connected between the interpole winding and the armature, they equalize satisfactorily. Could you tell me what is the trouble? C. F. C.

The trouble is probably due to the interpole field on one or both of the machines being too strong, and to obtain proper commutation the brushes have been given a backward shift. This will cause the interpole field to have a compounding effect, therefore it must be equalized the same as the series windings. If the machines are operating satisfactorily when equalizing the interpole windings, there is no reason for making any change in the connections. If it is desired to change the strength of the interpole field, a shim or two may be removed from between the interpoles and the field frame. This will allow the polepieces to be pulled back farther from the armature core, and the increased air gap will reduce the flux for a given number of ampere-turns. Another way would be to connect a shunt of proper resistance across the interpole-winding terminals. However, this may not give satisfaction if the load fluctuates rapidly through wide ranges, unless the shunt has the same inductance as the interpole windings. Of course, where the two machines are of the same capacity, the resistance of their series-field circuits should be the same.

Caloric Value of Coal from Chemical Analysis

What is the formula for determining the heat value of coal from the chemical analysis? C. F.

The formula most commonly used in calculating the calorific value of a fuel when based on the ultimate analysis, is known as Dulong's formula, which assumes that the heat generated by burning any fuel is equal to the sum of the "possible heats" generated by its component elements, less that portion of the hydrogen which combines with the oxygen in the fuel to form water. Assuming that the calorific value of a pound of carbon is 14,600 B.t.u.; of a pound of hydrogen is 62,000 B.t.u. and of a pound of sulphur is 4,000 B.t.u. Dulong's formula as generally used in the United States is,

B.t.u. per pound of the fuel =

$$14{,}600\,C + 62{,}000\left(H - \frac{O}{8}\right) + 4{,}050\,S$$

in which C, H, O, and S are respectively the weights of the carbon, hydrogen, oxygen and sulphur in a pound of the fuel.

The United States Geological Survey, with corrected calorific values for carbon, hydrogen and sulphur, uses the formula,

B.t.u. per pound of the fuel =

$$14{,}544\,C + 62{,}028\left(H - \frac{O}{8}\right) + 4{,}050\,S$$

Setting Steam Valves of Duplex Pump

What is the method of setting the steam valves of a duplex pump? A. R. D.

The general rule for setting the valves is to place the pistons of both sides at the center of the stroke and set the steam valves centrally over their ports. As there is no lap, the outer edges of the valves will be on line with the inner edges of the steam ports. In that position the valve-rod clearance or lost motion of each valve must be evenly divided so there will be the same amount of lost motion for movement of the valve in either direction.

To place the pistons at the center of the stroke, move them to contact first with one head and then with the other and mark the positions of each on its piston rod against the piston-rod gland. Then place a mark on each rod midway between the marks made at contacts and move the rods until the central marks come against the ends of the glands. The pistons then will be in central positions and the valve-motion arms should stand perpendicular to the piston rods. If that is not the case, the crosshead spools must be disconnected and the positions corrected. Next remove the steam-chest covers and place the slide valves centrally over the ports and adjust the lost motion so each valve will have the same clearance for movement in either direction.

Firebrick Troubles—Causes and Remedies*

THE one outstanding development in stoker performance during the last few years is the effective way in which forced draft has been applied to the burning of fuel. This has increased the range of fuels that can be advantageously burned and has permitted higher rates of combustion and greater fuel economy.

Along with these great advantages of forced draft have come many troubles with furnace lining, so that today the maintenance of the firebrick and tile of stoker-fired furnaces is in many plants a vexatious and serious matter. The result is that many are thinking of the limitations of the endurance of refractories as forming a barrier to the best stoker operations. There is, however, another side to this question, which this paper aims to bring out.

The point is that most of these troubles are not due to the unavailability of proper refractories, but to the common existence of many abuses.

The high-grade refractories of reputable manufacturers have kept pace with industrial developments and are equal to the tasks imposed by today's best practice in stoker-fired boiler furnaces. The emphasis here is on the words "best practice," for best practice protects the refractories from the abuses and unpardonable injuries due to improper design, construction and operation. Best practice means that, where trouble occurs, someone with a real knowledge of refractories as well as furnace conditions makes an analysis of the trouble and prescribes the proper remedy.

Firebricks are subjected to many abuses. A common one is to take an old and low-set boiler-furnace, designed for natural draft, and install forced-draft apparatus without making the necessary changes in the setting. The firebrick is the first thing to suffer from any such attempt. The liberation of large quantities of heat in a small combustion space does serious damage, which is often made worse by an unusual impinging of the flame upon the refractories—a sort of scouring action, accentuated by the small size of the combustion chamber. Other failures of furnace brickwork have been due to an attempt to make the small boiler compete in the matter of overloads with the large boiler.

In many plants there is no sufficient provision made to keep the water of boiler-washing periods away from the furnace work beneath it, in spite of the fact that water is one of the worst enemies of brick and tile. This applies particularly to arch tile.

FIG. 3. SIDE-WALL FAILURE DUE TO SPALLING
Spalling was caused by operating conditions such as high temperature and sudden temperature depressions.

	American Eng. Co. "Taylor"	Babcock & Wilcox Chain Grate	Brady J. A. Brandt's Trav. Grate	Burke Fur. Co. Trav. Grate	Comb. Eng. Corp. Underfeed & Trav. Grate	Detroit Side Feed	Green Eng. Co. Trav. Grate	Illinois Stoker Trav. Grate	Laclede Christy Trav. Grate	Murphy Iron Wks. Side Feed	ality Multi. Retort	Roney Jos.	Underfeed Stoker Co.	Westinghouse	Recommended Setting Height
BABCOCK & WILCOX a	11'-0"	12'-0"	12'-0"	12'-0"	12'-0"	11'-0"	12'-0"		12'-0"		11'-0"	11'-0"	11'-0"	11'-0"	12'-0"
B. & W. CROSS DRUM a	11'-0"	12'-0"	12'-0"	12'-0"	12'-0"	11'-0"	12'-0"		12'-0"		11'-0"	11'-0"	11'-0"	11'-0"	12'-0"
EDGE MOOR a	11'-0"	NO FIGURES	12'-0"	12'-0"	12'-0"	11'-0"	12'-0"		12'-0"		11'-0"	11'-0"	11'-0"	11'-0"	12'-0"
SPRINGFIELD a	11'-0"		12'-0"	12'-0"	12'-0"	11'-0"	12'-0"		12'-0"		11'-0"	11'-0"	11'-0"	11'-0"	12'-0"
KEELER-UNION IRON WKS. MURRAY-MCNAUL-GEARY a	11'-0"		12'-0"	12'-0"	12'-0"	11'-0"	12'-0"		12'-0"		11'-0"	11'-0"	11'-0"	11'-0"	12'-0"
HEINE a	11'-0"		12'-0"	10'-0"	12'-0"	11'-0"	12'-0"		12'-0" x / 7'-6" y		11'-0"	11'-0"	11'-0"	11'-0"	12'-0"
STIRLING b	4'-6"	5'-0" TO 7'-0"	7'-6"	7'-6"	7'-6"	6'-0"	5'-0" TO 7'-0"		6'-0"		7'-6"	7'-0"	4'-6"	4'-6"	7'-6"
BIGELOW HORNSBY c	4'-6"		6'-0"	6'-0"	6'-0"		8'-0"		6'-0"		7'-6"	6'-0"	4'-6"	4'-6"	7'-6"
CONNELLY b	4'-6"		8'-0"	8'-0"	8'-0"	7'-0"	6'-0"		8'-0"		7'-6"	7'-0"	4'-6"	4'-6"	8'-0"
KIDWELL b	4'-6"		8'-0"	8'-0"	8'-0"	7'-0"	5'-0"		8'-0"		8'-0"	7'-0"	4'-6"	4'-6"	8'-0"
BADENHAUSEN b	4'-6"		8'-0"	8'-0"	8'-0"	7'-0"	8'-0"		8'-0"		8'-0"	7'-0"	4'-6"	4'-6"	8'-0"
LADD b	4'-6"	NO FIGURES	6'-0"	6'-0"	6'-0"	6'-0"	5'-0"		6'-0"		6'-0"	6'-0"	4'-6"	4'-6"	6'-0"
ERIE CITY b	4'-6"		6'-0"	6'-0"	6'-0"	6'-0"	5'-0"		6'-0"		6'-0"	6'-0"	4'-6"	4'-6"	6'-0"
RUST b	4'-6"		6'-0"	6'-0"	6'-0"	6'-0"	5'-0"		6'-0"		6'-0"	6'-0"	4'-6"	4'-6"	6'-0"
WICKES c	4'-6"		6'-0"	6'-0"	6'-0"	6'-0"	4'-6"		6'-0"		6'-0"	6'-0"	4'-6"	4'-6"	6'-0"
HORIZ. RET. TUBULAR d			9'-0"	6'-6"	9'-0"	8'-0"	8'-0"		8'-0"		9'-0"	8'-0"			9'-0"

VARIES WITH HORSE POWER OF BOILER

a SETTING HEIGHT = FLOOR LINE TO BOTTOM OF FRONT HEADER. FOR BOILERS FIRED UNDER LOW HEADER DISTANCE IS TO BOTTOM OF LOWER HEADER
b FLOOR TO ℄ OF LOWER DRUM
c FLOOR TO ℄ OF TOP OF LOWER DRUM
d FLOOR TO BOTTOM OF SHELL
x VERTICAL BAFFLE
y BOX TILE-LOWER ROW OF TUBES

FIG. 1. MINIMUM BOILER HEIGHTS FOR GOOD MODERN PRACTICE
Table prepared by a joint committee representing the Stoker Manufacturers Association and the Boiler Manufacturers Association.

Carelessly operated stokers, resulting in bare grates and uneven fires, ruin brickwork. Where the fire burns thin, the draft picks up the ash and deposits it on the brick in excessive amounts. Later, the fire may be in excellent shape and the rate of burning increased. Thereupon the high temperature melts the deposited fly ash, and the resulting running slag is slowly taken up by the brick, thus lowering its vitality.

Members of the Stoker Manufacturers Association and of the Boiler Manufacturers Association, through a joint committee, have recently agreed on the minimum vertical heights that are considered in any way adequate for modern stoker practice. The figures agreed upon by these two associations are shown in Fig. 1. In establishing these minimum heights, the committee had uppermost in mind economy in the broadest sense. Consequently, reduced maintenance of brickwork was given careful consideration. A most important point in the matter of minimizing renewals of brickwork is that the first bank of tubes be so arranged that it can absorb by direct radiation a large portion of the furnace heat. This greatly reduces the temperature of the firebrick without a corresponding reduction in boiler efficiency.

*Abstract of Bulletin No. 2 (November, 1921), issued by Laclede-Christy Clay Products Co.

The principles underlying the selection and application of firebrick for various purposes, and for various parts of a furnace, are still far from being understood by most of those who deal with these materials. It would help if every plant engineer kept a record of the useful life of his refractories and compared this with the expected life. This record should be kept, not only on the basis of time, but also on the basis of tons of coal burned. The reason is that the life of the

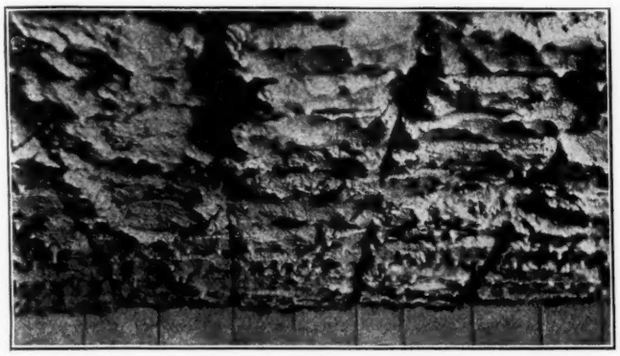


FIG. 2. FAILURE OF ARCH TILE DUE TO SPALLING

The remedy is to select tile and brick free from the likelihood of spalling, or to avoid sudden or wide changes in temperature.

firebrick depends to a large extent on the output that is obtained from the boiler.

The natural and frequent question, "What temperature will this firebrick stand?" is of far less importance than is generally believed. This, it is true, tells almost the whole story in the case of brick that is used as a backing for other brick exposed to the fire, but in the case of brick directly exposed to the fire there are many other elements that enter in, aside from the mere question of the temperature at which it melts or softens. Many failures are due either to the physical structure of the brick or the way it

FIG. 4. FAILURE CAUSED BY IMPROPER CEMENT

The cement used on the damaged portion not being suited to the furnace conditions or to the brick, flowed at furnace temperatures and cut the brick. The rest of the brickwork was laid up with a fireclay mortar containing a high percentage of burnt material.

reacts chemically with the slag that comes in contact with it. The real problem is expressed by the question, "What is the proper firebrick for my conditions?"

It is evident that the load on the brick is of great importance, and that care should be taken that this does not become excessive. Carelessness in laying the brick tends to increase the load at certain points of contact. This may start a failure at these points which will spread over the whole wall.

Little can be learned by inspecting or even testing a sample of firebrick. It is much better to allow the manufacturer to study the conditions and prescribe the proper brick for each place.

Figs. 2, 3, and 4 show instances of failures that were not due to any lack of quality in the brick, but rather to improper application or use.

The Chamber of Commerce Studying Waste

The United States Chamber of Commerce, a good idea of whose work is given in its letterhead by the phrase "Offices of the Nation's Business," has been accomplishing a good deal toward the same object as that of American Engineering Council's Committee on the Elimination of Waste, although it has attacked the problem from the business rather than the engineering point of view. It has apparently found about as many inefficient practices in the business end as the engineers have found in the mechanical departments.

The latest bulletin of the Chamber's Fabricated Production Department tells how a number of manufacturers in many different lines have been able to save money, simplify production and improve their service by cutting down the variety of their product and standardizing upon a smaller number of styles and sizes. It is pointed out that the tremendous variety of products in some cases, through the resulting small-lot production, has brought down the efficiency of large factories almost to the level of a small shop. The Government has not, of course, the authority to remedy this condition now, as it had during the war, but the Chamber is co-operating with the individual manufacturers and the trade associations in an effort to reduce these wasteful practices.

The Fabricated Production Department has gotten out a number of bulletins and pamphlets containing considerable practical information, especially on the subject of cost accounting and depreciation, which are distributed free, and a list of which may readily be obtained by addressing the Chamber of Commerce at Washington, D. C.

How to Figure the Weight of Any Gas

It is convenient to know the constant by which the weight of a cubic foot of any gas may be approximately determined from its molecular weight. At atmospheric pressure (14.7 lb. absolute) and 60 deg. F. the relation is as follows:

$$\textit{Weight per cubic foot} = \textit{molecular weight} \div 376$$
$$\textit{Cubic feet per pound} = 376 \div \textit{molecular weight}$$

The molecular weights of a few common gases are as follows: Nitrogen (N_2), 28; Oxygen (O_2), 32; Carbon Dioxide (CO_2), 44; Carbon Monoxide (CO), 28; Hydrogen (H_2), 2; Ammonia (NH_3), 17. For air use 28.8 (a weighted average based on four parts nitrogen and 1 part oxygen).

As an example, the weight of a cubic foot of CO_2 at 14.7 lb. absolute pressure and 60 deg. F. would be $44 \div 376 = 0.117$ lb., and the number of cubic feet in a pound would be $376 \div 44 = 8.55$.

The Widow's Lament

My Barney looked at his gage glass,
No water in it could he see.
He opened a valve to supply some—
Oh, bring back my Barney to me.

My Barney examined a gas tank,
Its volume of contents to see.
He lighted a match to assist him—
Oh, bring back my Barney to me.

My Barney was calking a steam line;
He would stop that darn leak or he'd see.
He neglected to turn off the pressure—
Oh, bring back my Barney to me.

News in the Field of Power

"Put Engineers in the Senate" Says Senator King

At the annual dinner of the Washington Society of Engineers, which was held at Washington, D. C., recently, the engineer came in for considerable praise at the expense of the statesman and politician. Senator King, one of the speakers, went so far as to say that the United States would be benefited if its Senators were to be dismissed and replaced by engineers. Lord Riddell, another speaker, felt that the progress of our civilization would be better represented by more statues to engineers and fewer to soldiers. Herbert Quick made a plea for more engineer representation in the affairs of local government and in the conduct of the railroads. The toastmaster was Col. E. Lester Jones, director of the Coast and Geodetic Surveys.

Shall We Come to This?

"Alice, you had better get a fire started under No. 3." "Mabel, that pump is giving trouble again; you had better tear it down and see what's wrong." "Genevieve, see if you can fix that lubricator." It sounds funny today, but who knows what the future will bring? The *New York Times* of Dec. 4 printed a photograph of Mrs. Carlia S. Westcott, of Seattle, Wash., who has just received the first marine engineer's license ever given in this country.

The photographer caught her with a rather embarrassed smile in the act of packing a valve. The packing is quite prominently shown, but for some strange reason (possibly editorial censorship) no mention is made as to what brand is being used. The opportunity seems too good to lose, and so doubtless we shall soon be reading advertisements saying "Mrs. Westcott uses Blank Brand Packing only."

Navy Selling Boilers and Engines

A number of small boilers and engines, located at the Portsmouth Navy Yard, are to be sold by the Government. Bids will be received up to Jan. 18 by the Senior Member, Board of Survey, Appraisal and Sale, Navy Yard, Washington, D. C., from whom the specifications may be obtained. Most of the engines are of considerably less than 50 hp. capacity, and most of the boilers are of Ward manufacture and have somewhat less than 200 sq.ft. of heating surface.

Attorney General Daugherty has directed the Bureau of Investigation of the Department of Justice to investigate retail prices, including those on fuels, in an effort to reduce them to proper levels. While no details as to the investigation were announced, the Attorney General said that in many places retail prices are too high. The co-operation of the Department of Commerce and of the states will be sought in reducing prices.

Another Thing to Know About Government Publications

After reading the article entitled "Things One Ought to Know About Government Publications," in *Power* for Dec. 20, H. P. Quick has very kindly sent some additional information that might prove valuable to a man in need of a particular Government publication. Mr. Quick has had the discouraging experience, which many others also have doubtless had, of having a request that he sent to the Superintendent of Documents returned with the curt notation "Exhausted," and was therefore compelled to look around for another source of supply. This he found in Loudermilk & Co., of Washington, who make a specialty of back numbers of Government documents and were able to supply his needs in this case. Thus it will doubtless be found advisable to try this company if the Government is unable to fill the order.

New Publications

Hendrick's Commercial Register of the United States. Published by the S. E. Hendricks Co., Inc., 2 West Thirteenth St., New York City. Thirtieth edition. Cloth, 8½ x 11½ in.; 2,324 pages. Price, $12.50.

"Hendricks" is well known and highly regarded as a directory of manufacturers and dealers, trade names, etc. Advertising matter is kept down to a reasonable limit, so that almost the entire book is taken up with condensed, valuable data. It is understood that over 100,000 names of individuals and firms are included, these being listed alphabetically and by trades or products. A valuable section lists trade names, so that when the brand or trade name of an article is known, the manufacturer may be found. The present edition has a larger page size than previous ones, making the book somewhat thinner and easier to handle, although some additional material is included.

Crain's Market Data Book And Directory Of Publications. Published by G. D. Crain, Jr., 417 South Dearborn St., Chicago, Ill. Cloth; 6 x 9 in.; 462 pages. Price, $5.

This directory of the various markets and of the publications that serve them, was gotten up primarily for those concerned with the planning and placing of advertising in business papers. The aim has been to define each market, to give the basic information and statistics on each trade, industry and profession, and to state the field of every trade, class and technical publication in the country. Other information given about these publications includes maximum and minimum page advertising rates, the publication and closing dates, the type page size, the agency discount (if any), and the circulation. The subject matter is indexed by markets and by publications.

Annual Report Of The Bureau Of Mines. By H. Foster Bain, director. Published by the Superintendent of Documents, Government Printing Office, Washington, D. C. Paper; 6 x 9 in.; 133 pages. Price, 10 cents.

A description of the organization and functions of the Bureau of Mines is given, as well as a complete report of work done during the fiscal year ended June 30, 1921. Considerable attention is devoted, of course, to fuel oil and coal, and interesting figures are given on the Government Fuel Yard in the District of Columbia.

An Investigation Of The Fatigue Of Metals. Bulletin No. 124 of the Engineering Experiment Station. By H. F. Moore and J. B. Kommers. Published by the University of Illinois, Urbana, Ill. Paper; 6 x 9 in.; 185 pages. Price, 95 cents.

The notable investigation that has been carried on for some time at the Engineering Experiment Station of the University of Illionis, and which was described at some length on page 922 of *Power* for Dec. 13, 1921, is reported in full in this pamphlet by the men who did the work. The methods used in setting the various materials, and the results secured, are given in great detail. The investigation has attracted considerable attention and is looked upon as an important addition to existing knowledge on the strength of materials, and so the bulletin should prove decidedly valuable to anyone having to meet problems of design.

Obituary

Gustavus O. Newman, chief engineer of the San Joaquin Light and Power Co., and of the Midland Counties Public Service Corporation, of California, died recently in Los Angeles. He was born in 1844 in Fortuna, Sweden, came to America in 1868 and joined the United States Geological Survey in 1881. In 1884 he became chief engineer of the Riverside California Water Co., leaving in 1897 for the San Gabriel Electric Co., in the same position, which he retained when the company was taken over by the Pacific Electric Light and Power Company.

Personals

H. Schreck has opened offices at 17 Battery Place, New York City, as a consulting engineer on marine and stationary Diesel engines.

V. C. Grant, formerly superintendent of the Enterprise (Oregon) Electric Co., has been placed in charge of the Ilwaco (Wash.) Light and Power Company.

Society Affairs

Coming Conventions

American Society of Civil Engineers—Annual meeting at New York City, Jan. 18-20. Secy., Elbert M. Chandler, 29 West 39th St., New York City.

American Society of Heating and Ventilating Engineers—Annual meeting at New York City, Jan. 24-26. Secy., C. W. Obert, 29 West 39th St., New York City.

American Institute of Electrical Engineers—Midwinter convention at New York City, Feb. 15-17. Secy., F. L. Hutchinson, 29 West 39th St., New York City.

American Society of Mechanical Engineers—Spring meeting at Atlanta, Ga., May 8-11. Secy., Calvin W. Rice, 29 West 39th St., New York City.

Cincinnati Section, A.S.M.E., will meet Jan. 19 for a discussion on "Gas Producers."

Cleveland Section, A.I.E.E., will meet Jan. 17 for a talk by A. C. Bishop on "Refrigeration."

New Haven Branch, A.S.M.E., is to meet Jan. 16 to hear Dr. Magnus W. Alexander speak on "Labor and the Present Industrial Situation."

Western-Washington Section, A.S.M.E. is to hold a meeting Jan. 15 at which Mr. Morrison will talk on "Hogged Mill Waste as Fuel."

Philadelphia Section, A.S.M.E., will hold a joint meeting Jan. 17 with the Engineers' Club of Philadelphia, at which "Finance and Engineering" will be the general topic.

The Associated Engineering Societies of St. Louis will hold their annual meeting Jan. 18. Dean Cooley, the new president of the Federated American Engineering Societies, will speak.

Worcester Section, A.I.E.E., is to meet Jan. 19 for an address by W. S. Murray, who directed the Superpower Survey, entitled "Superpower an Answer to the National Power Policy."

Chicago Section, A.S.M.E., will hold a dinner meeting at the Sherman Hotel Jan. 20 at 6:30 p.m. at which speeches will be made by President-elect Kimball and by S. W. Stratton, director of the Bureau of Standards.

The Indiana Engineering Society will hold its forty-third annual meeting Jan. 19-20 in the civil engineering lecture room at Purdue University, Lafayette, Ind. Most of the program will be of interest only to civil engineers, but two features will be the R. Sanford Riley moving picture of stoker operation, and an address on the "Engineer's License Law," by Prof. R. L. McCormick.

Business Items

The C. H. Wheeler Manufacturing Co. has secured H. W. Cross as head of the Boston office. He was for several years turbine engineer for the G. E. company in the Chicago office.

The Quigley Furnace Specialties Co., manufacturers of Hytempite and Insulbrix, has appointed the Federal Supply Co., East 79th St., Cleveland, Ohio, as its sales representative.

Leo Hudson and John P. Myron have formed an engineering partnership as Hudson & Myron, with offices at 808-810 Wabash Building, Pittsburgh, Pa. Mr. Hudson has been in private practice for 15 years on waterworks, power plants and other work. Mr. Myron was for 17 years secretary and engineer with the Pittsburgh Filter and Engineering Co.

The Green Engineering Co., East Chicago, Ind., has announced the opening of a direct branch sales office in the Monadnock Building, 53 West Jackson Blvd., Chicago, in place of the former agency representation. J. W. Himmelsbach has been appointed district manager for northern Illinois, northern Indiana, Iowa and Michigan, but the general sales office will remain at the factory.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run bases, f.o.b. mines):

Coal	Market Quoting	Dec. 26, 1921	Jan. 2, 1922
Pool 1,	New York	$3.05	$2.90@3.40
Pocahontas,	Columbus	2.15	2.00@2.25
Clearfield,	Boston	2.05	1.80@2.55
Somerset,	Boston	1.80	1.60@2.00
Pittsburgh,	Pittsburgh	2.15	2.10@2.20
Kanawha,	Columbus	1.90	1.75@1.95
Hocking,	Columbus	1.95	1.85@2.00
Pittsburgh No. 8	Cleveland	1.95	1.95@2.05
Franklin, Ill.,	Chicago	2.90	2.75@3.00
Central, Ill.,	Chicago	2.50	2.25@2.75
Ind. 4th Vein,	Chicago	2.70	2.40@2.75
Standard,	St. Louis	1.90	1.85@1.90
West Ky.,	Louisville	1.75	1.75@2.00
Big Seam,	Birmingham	2.10	1.90@2.30
S. E. Ky.,	Louisville	1.30	1.35@1.60

New York—On Jan. 5 Port Arthur light oil 22@25 deg. Baumé 4½c. per gal. 30@35 deg., 5½c. per gal., f.o.b. Bayonne, N. J.

Chicago—Dec. 29, for 24@28 deg. Baumé, 80@85c. per bbl.; 32@36 deg., 2⅜@2⅝c. per gal. in tank cars f.o.b. Oklahoma refinery, or freight adjusted.

Pittsburgh—On Jan. 3, f.o.b. refinery, Pennsylvania, 36@40 deg., 4¾c. Oklahoma, 24@30 deg., 50c. per bbl.; gas oil, 32@34 deg., 2¼c. per gal.; 36@38 deg., 2¾c., 38@40 deg., 3¼c. per gal.

St. Louis—Jan. 2 prices f.o.b. cars, tank lots; 24@26 deg. Baumé, 75c. per bbl.; 26@28 deg., 90c.; 28@30 deg., $1; 32@34 deg., 3c. per gal.

Philadelphia—On Jan. 3, 26@28 deg. Baumé, Oklahoma, 73@85c. per bbl.; 30@34 deg., Oklahoma (group 3) 2½@3c. per gal.; 16@20 deg., Seaboard, $1.15@$1.25 per bbl.

Cincinnati—Dec. 21, for 26@30 deg. Baumé, 5¼c.; Diesel 32@34 deg., 6c. per gal.; distillate 38@42 deg., 7c. per gal.

Cleveland—Dec. 21, 26@30 deg. Baumé, 4¼c. per gal.

New Plant Construction

PROPOSED WORK

Conn., New Britain—The Bd. Educ. is having plans prepared for a 3 story school on Washington St. About $367,000. D. K. Perry, 27 West Main St., Archt. Noted May 17.

N. Y., Astoria—(Long Island City P. O.)—A. J. Oliva, 717 Crescent St., plans to build a 6 story apartment on Jamaica and 4th Aves. About $350,000. Architect not selected.

N. Y., New York—The Bd. Educ., 500 Park Ave., is having plans prepared for a high school on Amsterdam Ave. and 183rd St. About $300,000. C. B. J. Snyder, 28th Floor, Municipal Bldg., Archt. and Engr.

N. Y., New York—The Bd. of Estimate, Municipal Bldg., will soon receive bids for 2 buildings for the Natural History Museum on 81st St. and Columbus Ave. About $1,500,000. Private plans.

N. Y., New York—The New York Times, Times Square, is having plans prepared for an 11 story, 100 x 143 ft. printing plant and office building at 217 West 43rd St. Ludlow & Peabody, 101 Park Ave., Archts. and Engrs.

N. Y., Brooklyn—The Bd. Educ., 500 Park Ave., New York City, is having plans prepared for a 5 story P. S. No. 188 on Neptune Ave. and 33rd St. About $75,000. C. B. J. Snyder, 28th Floor Municipal Bldg., Archt. and Engr.

N. Y., New York—C. D. Wykoff, c/o H. O. Chapman, Archt., 334 5th Ave., is having plans prepared for a 12 story apartment at 951 5th Ave. About $500,000.

N. J., Jersey City—C. F. Long, Archt., 665 Newark Ave., will take bids about Jan. 15, for a 3 story, 70 x 123 ft. parochial school, including a steam heating plant. Three 150 hp. boilers and accessories will be installed. Owner's name withheld.

Pa., Allentown—Queen City Hotel Co., c/o C. J. Otto, 130 North 7th St., is having preliminary plans prepared for a 14 story hotel at 133 North 7th St. About $1,100,000. Ritter & Shay, North American Bldg., Phila., Archts.

Pa., New Castle—The city is having plans prepared for a sewage disposal plant including a 30 x 40 ft. power plant and 4 60 x 100 ft. tanks. About $500,000. Fuller & McClintock, 180 Bway., New York City, Engrs.

Pa., Phila.—D. Crawford, Jr., 701 North 63rd St., is having plans prepared for a 10 story, 150 x 220 ft. apartment including a steam heating system on 39th and Chestnut Sts. About $500,000. Private plans.

Va., Hampton Roads—The Bureau of Yards and Docks, Navy Dept., Washington, D. C., plans to install motor generator set and switchboard in the Naval Operating Base Hospital, here. Spec. 4570.

Va., Virginia Beach—The Bybee's Natl. Chiropractic Sanitarium & Institute, Dr. H. R. Bybee, Pres., Arcade Bldg., Norfolk, Va., is having plans prepared for a 6 story, 100 x 125 ft. hospital and sanitarium including a steam heating system on Waterfront St., here. About $300,000. P. B. Moser, Dickson Bldg., Norfolk, Va., Archt.

Ga., Atlanta—The City Purch. Agt. will receive bids until Jan. 31 for filter plant of 7 units of 3,000,000 gal. daily capacity each with laboratory attached; 10,000,000 gal. reservoir; a wash water tank together with conduits; cast iron pipe lines with miscellaneous structures and connections to the present system.

O., Akron—The Mills Square Realty Co., c/o G. A. Grieble, Archt., 9th Garage Bldg., Cleveland, is having plans prepared for an 11 story office building including a steam heating system on Main and Bowery Sts. About $4,500,000.

O., Cleveland—The Superior 12th Co., c/o G. A. Grieble, Archt., 9th Garage Bldg., is having plans prepared for a 12 story office building including a steam heating system on East 12th St. and Superior Ave. About $2,500,000.

O., Columbus — H. C. Godman Co., 31 North 4th St., plans to build a 4 or 5 story, 147 x 230 ft. shoe factory on Starling St. About $308,000. Architect not selected.

O., Youngstown—The Youngstown Sheet & Tube Co., Stambaugh Bldg., is in the market for 10,000 kw. steam turbo alternator and surface condenser with cooling tower.

Ind., Elkhart—The Elkhart Hotel Corp., 212 Murdock Bldg., is having plans prepared for a 6 story, 83 x 139 ft. hotel and store building. About $350,000. Nicol, Scholer & Hoffman, Lafayette, Archts.

Ind., Fort Wayne—First and Hamilton Natl. Bank is having plans prepared for a 13 story, 90 x 150 ft. bank and office building. About $1,000,000. T. M. James, 3 Park St., Boston, Mass., Archt.

Ind., Fort Wayne—The Keenan Hotel Co., H. J. Keenan, Mgr. is having revised plans prepared for a 14 story, 90 x 110 ft. hotel on Harrison and Washington Sts. About $750,000. C. R. Weatherhogg, Citizens Trust Bldg., Archt.

Mich., Detroit—The Bd. Educ. & Library Comn., 1354 Broadway Ave., is having plans prepared for a 20 story, 150 x 250 ft. office building including a steam heating system on Gratiot Ave. and Farmer St. About $1,000,000. Malcolmson, Higginbotham & Palmer, 405 Moffat Bldg., Archts.

Mich., Detroit—The Bd. of Wayne County Road Comrs., J. S. Haggerty, Comr., 1103 Real Estate Exchange Bldg., will receive bids until Jan. 31 for the installation of electrical equipment for operating bridge including lighting, signals, telephones, etc.

Mich., Detroit—The Columbia Realty Co., c/o Merritt, Harrison & L. A. Turnock, Archts., 500 Bd. of Trade Bldg., Indianapolis, Ind., is having plans prepared for a 15 story, 93 x 160 ft. office building including steam heating system on Clifford and Columbia Sts. About $750,000.

Mich., Detroit — The Detroit Mortgage Corp., Real Estate Exchange Bldg., is having plans prepared for a 6 story, 67 x 151 ft. aparment including a steam heating system on John R St. and East Alexandrine Ave. About $510,000. A. Kahn, 1000 Marquette Bldg., Archt.

Mich., Niles — Estate of C. Chapin, C. Smith, Secy., c/o Niles City Bank, plans to build a 2 story hotel including a steam heating system. About $500,000. A. U. Rebori, 410 South Michigan Ave., Chicago, Ill., Archt.

Mich., Ypsilanti — The Owen Sanitarium Co. is having plans prepared for a sanitarium and industrial plant for bottling mineral water, making soap and tooth paste. About $800,000. Menefee & Streeter, 706 Marquette Bldg., Detroit, Archts.

Ill., Beardstown—The Bd. Comrs., J. H. Bowman, Chn., is having plans prepared for a drainage and steam power plant. About $175,000. Goodell & Millard, Natl. Bank Bldg., Engrs.

Ill., Chicago—The Morton Constr. Co., 127 North Dearborn St., is having plans prepared for a 14 story, 167 x 240 ft. hotel apartment including a steam heating system on Sheridan Rd. and Wellington St. About $3,000,000. Private plans.

Ill., Chicago—P. F. Olsen, Archt., 127 North Dearborn St., is receiving bids for three, 3 story, 142 x 247 ft. apartments including steam heating system on North Shore and Newgard Sts. for R. C. Biederman. Total cost about $450,000.

Ill., Chicago—E. C. Ruttenberg, 6 North Franklin St., is having plans prepared for a 10 story office and sale room including a steam heating system on Michigan and 13th Sts. About $450,000. Davidson & Weiss, 53 West Jackson Blvd., Archts.

Ill., Naperville—The city, c/o J. A. Reuss, Atty., Reuss State Bank Bldg., is having plans prepared for an addition to electric light plant. About $50,000. Private plans.

Wis., Beaver Dam—Bartelt Bros. Co., has purchased a site and plans to build a 1 and 2 story, 40 x 140 ft. ice cream factory on South Division St. About $100,000. Architect not selected. Several ice machines will be installed.

Wis., Brillion—The city, E. Gruett, Clk., is having plans prepared for a 2 story, 75 x 90 ft. power house and pumping station. About $65,000. W. C. Weeks, 720 Ontario St., Sheboygan, Archt. and Engr.

Wis., Milwaukee—The city has included $500,000 in 1922 budget for a municipal lighting plant. G. Staal, City Hall, Engr.

Wis., Sheboygan—The H. C. Prange Co., c/o H. C. Prange, 8th St. and Wisconsin Ave., plans to build a 4 story, 60 x 110 ft. power house and heating plant on 8th St. Cost between $150,000 and $175,000. Architect not selected. 350 to 500 hp. boilers will be installed and probably steam ash conveyors.

Ia., Storm Lake—The city is having plans prepared for waterworks improvements including new intakes, duplicate pump units of 400 gal. per min. capacity each, 250,000 gal. elevated steel tank, and 100 ft. steel tower. About $35,000. W. E. Buell Co., Davidson Bldg., Sioux City, Engr.

Minn., Duluth — The Water and Light Dept., at office of the manager, will receive bids until Jan. 20 for furnishing and erecting at the middle system pumping station, one 5,000,000 gal. electric centrifugal pump unit with all equipment. P. G. Phillips, Comr.

Minn., Virginia—The city, A. E. Bickford, Clk., is having plans prepared for a 4 story city hall building including a steam heating system. About $300,000. A. W. Kerr & Co., 240 La Salle Bldg., Minneapolis, Archts.

Kan., Independence—The Bd. Educ. received bids for a 3 story high school, boiler house and tunnel from P. J. Morley, 1701 Main St., Kansas City, Mo., $284,340; A. S. Hecker Co., 815 Reserve Bank Bldg., Kansas City, Mo., $367,000; and Murch Bros., R.-W. Exchange Bldg., Kansas City, Mo., $380,000. Separate contracts on heating, and ventilating system. Noted Dec. 6.

Kan., Larned—The city, W. H. Avery, Clk., will receive bids latter part of Jan. for a 1,000,000 gal. reservoir one 750 hp. engine driven generating unit with switchboard, five 150 hp. tub boilers, two 750 G.P.M. pumps, extensions to power house building, etc. About $90,000. W. B. Rollins, 208 Railway Exchange Bldg., Kansas City, Mo., Engr. Noted Nov. 22.

Mo., Warsau—W. R. Banks, Box 1005, is having plans prepared for a dam and a hydro-electric power plant. About $75,000. A. D. Beamer, LaMor, Mo., Engr.

Tex., Denison—The Missouri, Kansas & Texas Ry., Railway Bldg., St. Louis, Mo., will soon award the contract for a freight terminal consisting of switching yards, round house, warehouse, shops and other buildings, here. Total cost, about $3,000,000. F. Ringer, Ch. Engr. and A. L. Sparks, Archt., Missouri, Kansas & Texas Ry., Railway Bldg., St. Louis, Mo.

Wash., Tatoosh—The Bureau of Yards and Docks, Navy Dept., Washington, D. C., plans to build an operating and power building and install equipment in the Naval Radio Station here.

Cal., Auburn—The Central Sierra Power Co., New York, being organized, plans to strip 100,000 acres of Placer Co. land of timber aggregating 2,000,000,000 lumber ft., supply eastern Sacramento Co. with irrigation water and utilize the power that can be developed between North Fork of American River and Rubicon River to supply muncipalities and manufacturing concerns of Coast Dist. Plans include large mill, canals, main reservoir at French Meadows to have 60,000 acre ft. capacity, continuous flow of about 490 sec.ft. to power houses; power house 1, at Emigrant Gap, north fork of American River, develops 89,500 hp., power house 2, opposite Towle, north fork of American River develops 44,800., power house 3, near Colfax, develops 31,300 hp., power house 4, near Auburn, develops 26,800 hp. J. E. Barieau, Auburn, Engr. F. P. Tuttle, Jr., 428 13th St., Oakland, Atty. About $20,000,000.

Cal., Burbank — C. F. Braum Co., 604 Mission St., San Francisco, is having plans prepared for foundries, machine shops, storage rooms, etc., here. Cost, including tools, about $400,000. Work will be carried out under the supervision of the Engineering Dept. of the owners.

Cal., Fresno—The Brix Estate is having plans prepared for a 6 story, 100 x 150 ft. office building on North J St. About $350,000. E. Mathewson, Cory Bldg., Archt., H. J. Brunnier, Sharon Bldg., San Francisco, Engr.

Cal., Fresno — F. Dodd and F. W. Williams, c/o B. G. McDougall, Archt., 281 Bush St., San Francisco, is having preliminary plans prepared for a 10 story hotel and stores building on Tulare St. and Bway. About $500,000.

Cal., Napa—The Union Ice Co., 354 Pine St., San Francisco, is having plans prepared for a 1 story ice plant (20 ton per day capacity) and cold storage warehouse, here. About $50,000. W. H. Toepke, 942 Market St., San Francisco, Archt.

Cal., Sacramento — The City Comn. received bids for installing complete electrically driven pumping unit for Sewage Station 1 from Latourette-Fical Co., 3471 Sacramento Blvd., (a) $10,280, (b) $10,700, Byron Jackson pumps; California Hydraulic Engr. & Supply Co., 70 Fremont St., San Francisco, (a) $11,196, (b) $12,819; Mechanical Engr. & Supply Co., 906 7th St., (a) $12,100, (b) $14,055, Worthington pumps; J. C. Hobrecht & Sons, 1014 6th St., (a) $12,121, (b) $12,490, DeLaval pumps.

Cal., San Diego—The Bureau of Yards and Docks, Navy Dept., Washington, D. C., received bids for gas, water, sewer and electrical distributing systems at the Naval Base Hospital reservation from the General Electric Engr. Co., 449 West 42nd St., New York City, $52,400; W. E. Kerr and W. Simpson Constr. Co., 526 Marshstrong Bldg., Los Angeles, $55,000; DeWard & Cobham, 207 Granger Bldg., $61,800. Spec. 4559. Noted Dec. 20.

Cal., San Francisco—The Clift Hotel Co. is having plans prepared for a 14 story hotel on S.E. Geary and Taylor Sts. About $750,000. G. A. Applegarth, Claus Spreckels Bldg., Archt.

Ont., Blenheim—The Council, G. W. Riseborough plans electric light and power distribution system. About $40,000. Work to be carried out under the direction of Hydro Power Comn. J. N. Wilson, 190 University Ave., Toronto, Engr.

Ont., Essex—The Bd. Waterworks is in the market for oil engines for operating waterworks pumps, replacing electrical driven pumps. M. Gilboe, Supt. Noted Dec. 20.

Ont., London—The Utilities Comrs., Hydro Bldg., plans extending wells system. The Ohio Wells Digging Co. was given original contract for experimental wells and now have another contract to locate additional wells. The pumping and piping will be done by Utilities Bd. Prices wanted on pumps and pipe. E. V. Buchanan, Hydro Bldg., Engr.

Ont., Simcoe—The Utilities Bd., A. T. Sihler, plans to install additional equipment in electric light plant to increase capacity.

CONTRACTS AWARDED

Mass., Lawrence—The city has awarded the contract for a 4 story, 115 x 317 and 92 x 147 ft. addition to high school to G. Dose Engr. Co., 43 West 27th Street, New York City, $758,700. Noted Nov. 29.

Pa., Erie—The Erie Brewing Co. has awarded the contract for converting brewery into a 50 ton capacity ice plant and a 4,400 ton ice storage plant, to H. Skenk Co., 12th and Sassafras Sts.

Va., Richmond—C. M. Robinson, Archt., 508 Times Dispatch Bldg., has awarded the contract for a 4 story high school on Marshall St. between 8th and 9th Sts., to A. M. Walkup & Co., 746 North 17th St., $341,800. A steam heating system will be installed.

N. C., Winston-Salem—The Bd. of Trustees of the Memorial High School has awarded the contract for a power plant for the R. J. Reynolds Memorial High School building of Academic Arts to the DuPont Engr. Co., DuPont Bldg, Wilmington, Del. $28,250.

Wis., Fond-du-Lac—The Eastern Wisconsin Elec. Co., M. H. Frank, Mgr., 15 North Main St., has awarded the contract for a 1 story, 35 x 90 ft. electric sub-station, to Immel Constr. Co., 200 North Main St., $45,000. Equipment contract to be awarded later.

Wis., Hortonville—W. L. Schroeder will build a 1 story, 50 x 120 ft. canning factory. About $50,000. Canning machinery and several 100 hp. boilers will be installed. Work will be done by day labor.

Wis., Milwaukee—The Bd. of Mgrs. of Natl. Homes for D. V. S. has awarded the contract for a service hospital including various buildings at the Soldiers Home to H. Schmitt & Son, 430 Farwell Ave., $1,094,000. Noted Dec. 6.

Minn., Duluth — The Great Northern Power Co., West Superior St., will build a 1 story, 25 x 50 ft. electric sub-station on 4th St. and 8th Ave. East. About $25,000. Work will be done by day labor.

Mo., Kansas City—The Superior Ice & Storage Co., A. L. Williams, Lee Bldg., will build an ice plant on 2nd and Main Sts. About $150,000. Owner will build by day labor. Noted Oct. 18.

Mo., St. Louis—J. H. Belz Provision Co., 2035 Gravois Ave., has awarded the contract for a cooler building at 3601 South Bway., to the Kellerman Constr. Co., Victoria Bldg. About $40,000.

Cal., Los Angeles—The Automobile Club of South California, c/o Hunt & Burns, Archts., 701 Laughlin Bldg., has awarded the contract for a 3 story, 207 x 267 ft. office building on 26th and Figueroa Sts. to C. J. Ruback Co., Mer. Natl. Bank Bldg., $500,000. A steam heating system will be installed.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

SINCE LAST MONTH

Black and galvanized wrought steel pipe discounts increased on the new Pittsburgh basing card. Mill changes quickly reflected in warehouse quotations. Refractories prices down, making the second price reduction within the last two months. Cold finished steel products declined 33c. in New York and 28@30c. per 100 lb. in Chicago. Slight rise in babbitt metal in New York, Cleveland and Chicago.

Increased discounts quoted on high pressure, asbestos pipe and boiler covering and rubber belting. Packing prices substantially reduced. Wiping cloths quoted in Cleveland at $50@$55 as against $55@$65 per 1,000, last month.

Linseed oil down 1c. in Cleveland and 2c. per gal. in Chicago. New York prices firm throughout the month.

POWER-PLANT SUPPLIES

HOSE—

	Fire	
Underwriters' 2½-in.		56c. per ft.
Common, 2½-in.	80 per ft. list less	50–5%

	Air	
	First Grade	Second Grade
¾-in. per ft.	$0.38	$0 22½

Steam—Discounts from List

First grade...40–10% Second grade...50–5% Third grade....50–10–5%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition..... 60–10% Best grade..... 50–10%

LEATHER BELTING—Present discounts from list in fair quantities (½ doz rolls):

Light Grade	Medium Grade	Heavy Grade
50–5%	45%	40%

RAWHIDE LACING { For cut, best grade, 50–10%, 2nd grade, 60%. For laces in sides, best, 41c. per sq.ft.; 2nd, 39c. Semi-tanned: cut, 50%; sides, 43c. per sq.ft.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam	$0.90
Asbestos for high-pressure steam	1.80
Duck and rubber for piston packing	.90
Flax, regular	1.10
Flax, waterproofed	1.70
Compressed asbestos sheet	.90
Wire insertion asbestos sheet	1.30
Rubber sheet	.45
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.59
Rubber sheet, cloth insertion	.30
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.40
Asbestos wick, ½- and 1-lb. balls	.75

PIPE AND BOILER COVERING—Discounts are as follows:

85% magnesia high pressure		50% off
For low-pressure heating and return lines	4-ply	60% off
	3 ply	62% off
	2-ply	64% off

PORTLAND CEMENT—New York, $2.30 without bags, in cargo lots delivered on job. Bag charge of 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles, tees, and plates, all $2.78 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York Current	Cleveland	Chicago
White	7.50@10.00	12.00	12.00
Colored mixed	5.50@9.00	9.00	10.00

WIPING CLOTHS—Jobbers' price per 1,000 is as follows:

	13½ x 13½	13½ x 20½
Cleveland	$50.00	$55.00
Chicago	55.00	65.00

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$0.72	$0.76	$0.74

WHITE AND RED LEAD—Base price per pound:

	Red				White	
	Current		1 Year Ago		Current	1 Yr. Ago
	Dry	In Oil	Dry	In Oil	Dry and In Oil	Dry and In Oil
100-lb. keg	12.25	13.75	15.50	17.00	12.25	15.50
25- and 50-lb. keg	12.50	14.00	15.75	17.25	12.50	15.75
12½-lb. keg	12.75	14.25	16.00	17.50	12.75	16.00
5-lb. cans	15.25	16.75	18.50	20.00	15.25	18.50
1-lb. cans	17.25	18.75	20.50	22.00	17.25	20.50

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ⅞ and smaller	50–10%	60–10–10%	65–5%
Tinned	50–10%	60–10–10%	4½c. per lb. net

Structural rivets, ½, ⅝, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.

New York.....$3.50 Chicago.....$3.43 Pittsburgh...$2.25@2.40

Boiler rivets, same sizes:

New York.....$3.60 Chicago.....$3.53 Pittsburgh....2.35@2.50

REFRACTORIES—Prices in carlots:

Chrome brick, eastern shipping points	net ton	$35@41
Chrome cement, 40@45% Cr_2O_3	net ton	22@25
Magnesite brick: 9-in. straight	net ton	45@50
Magnesite brick: 9-in. arches, wedges and keys	net ton	49.50@55
Magnesite brick: Soaps and splits	net ton	63@70
Silica brick: Chicago district	per 1,000	35.00
Silica brick: Birmingham, Ala.	per 1,000	28.00
Silica brick: Mt. Union, Pa.	per 1,000	28@30
Chrome ore, crude, 40@45%	net ton	15@17
Chrome ore crude, 45@50%	net ton	16@18
Magnesite dead burn (Imported)	net ton	28@30
Clay brick, 1st quality, 9 in. shapes, Pennsylvania	per 1000	35@40
Clay brick, 1st quality, 9 in. shapes, Ohio	per 1000	35@40
Clay brick, 1st quality, 9 in. shapes, Kentucky	per 1000	35@40

BABBITT METAL—Warehouse prices in cents per pound:

	New York	Cleveland	Chicago
Best grade	24.62½	43.75	36.00
Commercial	9.87½	13.50	9.00

COLD FINISHED STEEL—Warehouse prices are as follows:

	New York	Chicago	Cleveland
Round shafting or screw stock, per 100 lb. base	$3.55	$3.55	$3.50
Flats, square and hexagons, per 100 lb. base	4.05	4.05	4.00

BOILER SPECIALTIES—F. o. b. New York or Jersey City, discounts on list:

	Current
Copper ferrules	75%
Boiler flanges	55%
Boiler stay bolts	60%
Boiler patch bolts	Net list
Boiler fitting-up bolts	50%
Pressed steel boiler lugs	10%
Pressed steel boiler hangers	10%

WROUGHT PIPE—The following discounts are to jobbers for carload lots on the latest Pittsburgh basing card:

	Steel Black	Steel Galv.		Iron Black	Iron Galv.
	BUTT WELD				
Inches			Inches		
1 to 3	71	58½	¼ to 1½	44½	29½
	LAP WELD				
2	64	51½	2	39½	25½
2½ to 6	68	55½	2½ to 4	42½	29½
7 to 8	65	51½	4½ to 6	42½	29½
9 and 12	64	50½	7 to 12	40½	27½
	BUTT WELD, EXTRA STRONG, PLAIN ENDS				
1 to 1½	69	57½	1 to 1½	44½	30½
2 to 3	70	58½			
	LAP WELD, EXTRA STRONG, PLAIN ENDS				
2	62	50½	2	40½	27½
2½ to 4	66	54½	2½ to 4	43½	31½
4½ to 6	65	53½	4½ to 6	42½	30½
7 to 8	61	47½	7 to 8	35½	23½
9 to 12	55	41½	9 to 12	30½	18½

BOILER TUBES—Following are prices in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers:

Size	Lapweld Steel	C. C. Iron	Seamless Steel
1	.....	.....	$0.22
1¼	.....	.....	.21
1½	.....	.....	.1755
1¾	$0.2134	$0.2404	.1936
2	.1638	2069	.1701
2¼	.1872	2364	.1944
2½	.1950	2768	.2280
2¾	.2216		.2584
3	.2470	3505	.2698
3½	.2610	4039	.2925
3½	.2784	4308	.3120
4	.3538	5475	.3965

Tubes 2½ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.

These prices are net per lineal foot based on stock lengths. If cut to special lengths, billing will be based on the entire stock lengths.

In addition to the above, standard cutting charges are as follows:

1¼ in. to 2 in. diameter, 5c. per cut. 2¾ in. diameter, 7c. per cut
2½ in. diameter, 6c. per cut. 3 in. diameter, 9c. per cut
3¼ in. to 4 in. diameter, 10c.

ELECTRICAL SUPPLIES

ARMORED CABLE—Price per 1,000 ft.—5 per cent 10 days.

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$ 45.00	$138.00	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	

From the above lists discounts are:

Less than coil lots	25%	15%
Coils to 1,000 ft	35%	30%
1,000 ft. and over	40%	35%

BATTERIES, DRY—Regular No. 6 size red seal, Columbia, or Ever-Ready:

	Each, Net
Less than 12	$0.40
12 to 50	.34
50 to 125 (bbl.)	.30½
125 (bbl.) or over	.29

CONDUIT, Price per 1,000 ft.; **ELBOWS AND COUPLINGS**, Per 100 pieces, f. o. b. New York, with 10-day discount of 5 per cent.

Size, In.	Conduit Black 2,500 to 5,000 Lbs.	Conduit Galvanized 2,500 to 5,000 Lbs.	Elbows Black 2,500 to 5,000 Lbs.	Elbows Galvanized 2,500 to 5,000 Lbs.	Couplings Black 2,500 to 5,000 Lbs.	Couplings Galvanized 2,500 to 5,000 Lbs.
½	$45.97	$50.25	$ 9.54	$10.40	$4.09	$4.51
¾	58.28	64.28	12.59	13.81	5.87	6.43
1	83.87	92.18	17.61	19.49	7.53	8.67
1¼	114.00	125.00	24.75	27.15	10.68	11.76
1½	136.20	149.50	32.78	35.90	13.19	14.56
2	172.84	191.30	60.44	66.88	17.58	19.27
2½	288.00	316.15	98.83	108.80	25.19	27.60
3	377.00	414.00	265.22	291.50	37.90	41.60
3½	478.00	566.15	570.06	627.40	51.05	56.20
4	586.00	644.20	670.00	737.50	62.74	68.94

CONDUIT NON-METALLIC, LOOM—

Size I. D., In.	Feet per Coil	List, Ft.
⅜	250	$0.05½
½	250	.06
⅝	250	.09
¾	200	.12
⅞	200	.15
¾	150	.18
1	100	.25
1¼	100	.35
1½	Odd lengths	.40
2	Odd lengths	.55

1000 ft. and over.... 65%
Coils..... 55%
Less coils, 45%

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.08	D. P. D. B.	$0.32
D. P. M. L.	.15	T. P. to D. P. S. B.	.18
T. P. M. L.	.23	T. P. S. B.	.29
D. P. S. B.	.17	T. P. D. B.	.47

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.40	$1.08	$1.35
T. P. M. L.	.57	1.50	1.95
D. P. S. B.	.51	1.35	.....
T. P. S. B.	.96	1.90	.....
D. P. D. B.	.72	2.45	.....
T. P. D. B.	1.58	4.40	.....
T. P. to D. P. D. B.	1.06	3.10	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton twisted	$13.10
No. 16 cotton twisted	16.50
No. 18 cotton parallel	16.00
No. 16 cotton parallel	20.15
No. 18 cotton reinforced heavy	22.85
No. 16 cotton reinforced heavy	27.40
No. 18 cotton reinforced light	17.50
No. 16 cotton reinforced light	23.90
No. 18 cotton Canvasite cord	16.50
No. 16 cotton Canvasite cord	19.35

FUSES, ENCLOSED—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30-amp.,	100	$0.20	3-amp. to 30-amp.,	100	$0.40
35-amp. to 60-amp.,	100	.30	35-amp. to 60-amp.,	100	.60
65-amp. to 100-amp.,	50	2.90	65-amp. to 100-amp.,	50	1.50
110-amp. to 200-amp.,	25	3.00	110-amp. to 200-amp.,	25	2.50
225-amp. to 400-amp.,	25	5.60	225-amp. to 400-amp.,	25	5.50
425-amp. to 600-amp.,	10	9.50	450-amp. to 600-amp.,	10	8.00

Discount: Less 1-5th standard package, 50%; 1-5th to standard package, 55%; standard package, 65%.

RENEWABLE FUSES, ENCLOSED—

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50 ea.	$1.10 ea.	100	10
35 to 60-amp	1.00 ea.	1.25 ea.	100	10
65 to 100-amp	2.00 ea.	3.00 ea.	50	5
110 to 200-amp	4.00 ea.	5.00 ea.	25	5
225 to 400-amp	7.50 ea.	11.00 ea.	25	1
450 to 600-amp	11.00 ea.	16.00 ea.	10	1
450 to 600-amp	11.00 ea.	16.00 ea.	10	1

RENEWAL LINE FOR ABOVE FUSES—

1 to 30	$0.30 ea.	$0.05	100	100
35 to 60	.05 ea.	.06	100	100
65 to 100	.10 ea.	.10	50	50
110 to 200	.15 ea.	.15	25	50
225 to 400	.30 ea.	.30	25	25
450 to 600	.60 ea.	.60	10	10

Discount Without Contract—Fuses:

Broken carton	5%
Unbroken carton but less than std. pkg.	22%
Std. pkg.	40%

Discount Without Contract—Renewals:

Less than std. pkg.	Net list
Standard package	40%

Discount With Contract—Fuses:

Broken cartons	10%
Unbroken cartons but less than standard package	26%
Standard package	42%

Discount With Contract—Renewals:

Less standard package	Net list
Standard package	42%

FUSE PLUGS, MICA CAP

0-30 ampere, standard package	$2.40
0-30 ampere, less than standard package	2.75

LAMPS—Below are present quotations in less than standard package quantities

Straight-Side Bulbs Mazda B— Watts	Plain	Frosted	No. in Package	Pear-Shaped Bulbs Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.40	$0.45	100	75	$0.75	$0.80	50
15	.40	.45	100	100	1.10	1.20	24
25	.40	.45	100	150	1.55	1.65	24
40	.40	.45	100	200	2.10	2.25	24
50	.40	.45	100	300	3.15	3.35	24
60	.45	.50	100				12
				500	4.60	4.85	12
				750	6.50	6.85	8
				1,000	7.50	7.85	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.19
Composition 2-piece attachment plug	26
Swivel attachment plug	12
Current taps	36

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o. b. New York.

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$ 6.75	$ 8.57	$10.64	$16.75
12	9.27	11.30	13.65	25.88
10	12.45	14.52	16.87	33.54
8	16.80	18.96	22.55	44.50
6	.....	.....	33.79	.....
4	.....	.....	45.51	.....
2	.....	.....	67.74	.....
1	.....	.....	89.26	.....
0	.....	.....	106.63	.....
00	.....	.....	126.92	.....
000	.....	.....	153.64	.....
0000	.....	.....	183.84	.....

SOCKETS, BRASS SHELL—

½ In. or Pendant Cap Key Each	Keyless Each	Pull Each	¾ In. Cap Key Each	Keyless Each	Pull Each
$0.33	$0.30	$0.60	$0.39	$0.36	$0.66

Less 1-5th standard package..... 15%
1-5th to standard package..... 30%
Standard package..... 45%

WIRE, ANNUNCIATOR AND DAMPPROOF OFFICE—

No. 18 B. & S. regular spools (approx. 8 lb.)	34c. lb.
No. 18 B. & S. regular 1-lb. coils	35c. lb.

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	33c. lb
Rubber tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	33c. lb
Wire solder, less 100 lb. 27c. lb., 100 lb. lots	23c. lb
Soldering paste, 2 oz. cans	$1.00 doz.

SWITCHES, KNIFE—

TYPE "C" NOT FUSIBLE

Size, Amp.	Single Pole, Each	Double Pole, Each	Three Pole, Each	Four Pole, Each
30	$0.42	$0.68	$1.02	$1.36
60	.74	1.22	1.84	2.44
100	1.50	2.50	3.76	5.00
200	2.70	4.50	6.76	9.00

TYPE "C" FUSIBLE, TOP OR BOTTOM

30	.70	1.06	1.60	2.12
60	1.18	1.80	2.70	3.60
100	2.38	3.66	5.50	7.30
200	4.40	6.76	10.14	13.50

Discounts:

Less than $10.00 list value	Net List
$10 to $25 list value	15%
$25 to $50 list value	20%
$50 to $200 list value	30%
$200 list value or over	35%